

Copy of Public Works Department G.O. No. 440C/189C-1939 dated May 4, 1943, to the Deputy Commissioner, In-charge Kumaon Division.

SUBJECT : SAFETY OF HILL SLOPES AROUND NAINI TAL.

With reference to the correspondence ending with your letter No. 633/XXIII-20, dated November 12, 1942, on the subject noted above I am directed to say that the recommendations contained in the various minutes of the meetings of the safety of Hillside Committee and sub-committee have been considered by Government in consultation with the Chief Engineer, Buildings and Roads Branch, and they accept all the recommendations.

2. As regards recommendation No. 8 of the meeting of the sub-committee held on October 2, 1942, I am to point out that Government do not agree with your suggestion that single unit foundation need not be insisted upon during the war where no part of the foundation is on filling, because this will lead to difficulties. Government are advised that, in order to get his foundations on solid ground, the builder is likely to cut back further into the hillsides, which will be an undesirable move. It is, therefore, necessary that all buildings to be constructed in future in Naini Tal should be on earthquake proof lines and that, as a general rule, unit foundation should be insisted on. In exceptional cases, however, where unit foundation is likely to lead to serious inconvenience, permission may be given by the Board, with your concurrence so far as the exempted areas are concerned, and with that of the Superintending Engineer, III Circle, Provincial Works, in the case of the prohibited areas.

3. The above will necessitate amendment of the building byelaws of the Naini Tal Municipality, which the Municipal Board should be asked to do. The amendments should be submitted to Government in the Municipal Department for approval before you confirm them.

No. 2655/XXIII-20

Kumaon Deputy Commissionership.

Dated Naini Tal, May 13, 1943

Copy forwarded to the Chairman, Municipal Board, Naini Tal for information and necessary action, with reference to his letter no. 9079/XII-348, dated October 26, 1942.

G.B. Sarwal
for Deputy Commissioner
In charge Kumaon Division.

Copy of special resolution no. 7 of a meeting of the Municipal Board of Naini Tal, held on the 31st May 1943.

G.O. No. 440C/189C-1939 dated May 4, 1943 stating that the recommendations made by the Safety of Hill Sides Committee have been accepted by Government and that the Municipal Board be asked to make necessary amendments in their building byelaws copy received under Deputy Commissioner in Charge Kumaon Division's endorsement No. 2655/XXIII-20 dated May 13, 1943.

Resolved that the building byelaws be re-drafted by the sub-committee consisting of the Chairman, Municipal Board, Mr. B. Culley Pt. D.K. Pandey and Mr. F.G. Brandon.

OFFICE OF THE EXECUTIVE ENGINEER,
Kumaun Provincial Division . 91.

No. 2222 dated N A I N I T A L, April 5, 1943.

To
The Secretary

Municipal Board, Naini Tal.

Geological report on the stability of the Hillside at Naini-Tal by Mr. J.B. Auden.

No. 362 Sir

With reference to your letter No.12465/XII-348 dated February 10, 1943, I have the honour to enclose herewith a copy of the report mentioned above, for reference and record in your office.

Enclosure:
The report.

I have the honour to be
Sir,
Your most obedient servant,

ATTESTED.

Sd. Z.A. Vahidy,
Executive Engineer,
Divisional Head Clerk, Kumaun Provincial Division.
Executive Engineer's Office,
Kumaun Provincial Division.

5. Mitigating Factors concerning the Extended Prohibited Area..

XII. POSSIBLE REMOVAL OF BAN FROM EXTENDED PROHIBITED

XIII. REVISION OF PROHIBITED AND SAFE AREAS

1. General question of safety
2. The old Prohibited Area, north-east of the Lake
3. The Prohibited Area south-west of the Lake.
4. Revision of Categories advised.

XIV. SUMMARISED STATEMENT OF CONDITIONS PERMITTING CONSTRUCTION.

- A. Lower Portions of Hill Sides, near Lake.
- B. Upper Portions of Hill Sides.
- C. General conditions.

by

J. B. Auden, .

Geological Survey of India.

PART I.

1. INTRODUCTION.

Since the 1867 landslip, and particularly since that of 1880, numerous committees of engineers and geologists have reported on the stability of the hillsides around Naini Tal. The following geologists have worked on this problem :- R.D.Oldham, C.S.Middlemiss, G.L.Griesbach, T.H.Holland, and A.L.Coulson.

The last examination was made by Coulson in 1939, and in his Report on the Safety of Certain Areas around Naini Tal he recommended (Recommendation No. 57) that a geologist should be called in to advise on the hillsides in 1942, five years after the 1937 Committee sat. I was deputed by the Director of the Geological Survey of India to visit Naini Tal and be a member of the Hillside Committee. My examination of the hill sides lasted from July 3rd to 20th, 1942.

1. Acknowledgments.

I wish here to record my thanks to Mr.M.B.Hatfield,I.S.E Executive Engineer, for much hospitality, and assistance in placing his records at my disposal. We discussed many of the problems dealt with in this report and inspected together certain of the sites. Mr. Bhola Dutt Pant, Assistant Engineer, was also of great assistance to me.

In addition, I had the benefit of a helpful discussion with Mr.T.J.C.Acton,I.C.S., Deputy Commissioner-in-charge, who was Chairman of the Hillside Committee.

My visit was prolonged by the abnormal monsoon, which greatly hampered field work.

2. Nature of the Report.

This report is unfortunately incomplete as it was not possible to examine all the points put to me by the Committee in the time which was available.

In the course of the investigation it became apparent that besides specific points which required geological advice, larger issues arose which were not strictly within my terms of reference but which it seemed desirable to discuss, since they outweigh in importance the individual localised problems concerning particular sites. The conclusions arrived at towards the end of this report not intended to be categorical, but are offered for the consideration of the Hillside Committee when it next meets at the end of September or early in October. It has appeared evident that more use should be made of the geological map made by Holland in 1895, in which slopes of a certain steepness are shown by a dark colour, and that this might now, subject to modifications, and certain conditions with regard to observations being satisfied, be a better basis for determining safe and unsafe areas than the somewhat arbitrarily demarcated areas which are at present the basis of the regulations concerning building.

3. Meetings of the Hillside Committee. 3.7.42 and 8.7.42.

Meetings of the Hillside Committee were held, under the Chairmanship of Mr. T.J.C. Acton, I.C.S., Deputy Commissioner-in-Charge, on the 3rd and 8th of July. 42

The 84 detailed recommendations made in the two Reports of Dr. Coulson, written in 1939, were read out, and the action which had been taken thereon by the P.W.D. during the last three years was discussed. The Chairman of the Municipal Board raised certain points, in a Memorandum dated 1.7.42, which were discussed, and some of which required investigation by a geologist. Yet other problems arose which are embodied within this report.

In general, the action taken by the P.W.D. has corresponded closely to the recommendations suggested by Coulson in his two reports....

reports. The few instances where the recommendations have been open to a difference of opinion are cited below.

Safety of Certain Areas.

Rec. 4,5,13.

The Chief Engineer disagreed with Coulson's suggestion that the buildings should be totally demolished. I agree with the Chief Engineer. The structural alterations carried out by the P.W.D. seem perfectly adequate. There is a point in the taking of precautionary measures beyond which the costs involved outweigh any doubtful increment in safety gained.
(see p.49).

Rec. 58

This is irrelevant. It does not need a geologist to point out the dust nuisance.

Power Pipe Line.

Almost all the recommendations have been carried out in toto.

Rec.7.

I do not consider action need be taken on this recommendation.

21-23.

Out of the 17 bed-bars which were recommended for construction, only one, No.15, has not been done. Unfortunately our attempt to visit this site was frustrated by the weather.

Rec. 24.

I confess I do not see the seriousness of the situation portrayed by Coulson, near Tulsi Das's Cottage. It is true that the Krol Red Shales are liable to slip, but the dips of both these and the lower Krol slates below them are northwards into the spur, and the spur is bounded on the east and west by lined channels (the Ballia Nala and the Danda House drain) so that lateral erosion at the foot is not possible. Tulsi's cottage is a remarkable lean-to hut and might reasonably be left to more leisured times to destroy, if by then it has not already collapsed of its own accord. The cultivation on this spur should be stopped, as recommended by Coulson.

4. Questions on which Geological Advice is required.

Isolated Enquiries.

- (a) 9 building sites
- (b) 3 reservoir sites
- (c) sewage settling tank
- (d) safety of the Power Pipe Line
- (e) unstable areas
 - i. Fine View
 - ii. Killarney
 - iii. Purbeck Lodge
 - iv. Depot Road.
- (f) adit drainage.

General Enquiry

(a) Sher-ka-Danda Hill

(b) I have added a discussion on the Prohibited and Safe areas.

II. GEOLOGY.

1. Stratigraphical Succession.

The only published account of the geology of Naini Tal was written by Middlemiss over 50 years ago (Rec.Geol.Surv.Ind.XXIII, 1890). In 1895 Holland produced a more detailed map of the lake region on a scale of 10" = 1 mile and laid stress on those portions of the slate outcrops which lie outside the critical angle of 37° . This is most important from the point of view of hillside stability.

In 1935 I spent one night at Naini Tal, and a visit to China suggested certain correlations with rocks closer to Simla. In 1938 Swiss geologists Heim and Gansser spent a few days examining the structure, while en route to their main area in the higher ranges. Their description is confined to 2 pages in Denkschr.d.Schweiz.Nat.Ges., Bd.LXXIII, Abh.1, pp.25-27, published in 1939. Coulson has quoted verbatim from this account.

This is not the occasion in which to consider the geology of the area in detail, but a few points may be mentioned. As a consequence of field work carried out intermittently during the last 14 years has been possible to connect the Simla area with those of Lansdown and Naini Tal, and certain correlations now suggest themselves with a certainty which formerly could only be hazarded.

J.B.Auden: Geology of the Krol Belt Rec.Geol.Surv.Ind., LXVII, The structure of the Garhwal Himalaya. Op.Cit. 71, (1937).

Middlemiss has two divisions:- the Massive Limestone, (shown by Holland to be a dolomite), and the Purple Slate series, in which there are bands of limestone shown with the same colour on the geological map as the massive limestone. Such bands are seen on China Sher-ka-Danda.

In reality, the so called Purple Slate series are composite

... stages worked out near Simla and in Tehri Garhwal

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The following are the correlations suggested between the outer ranges north-west and south-east of the Ganges river.

West of Ganges.	South-East of Ganges and Naini Tal.	Localities at Naini Tal.	C.S. Middlemiss 1890
Tal Quart	Upper Tal Quartzites and sandstones	Lands End Govern-ment High School	Not recognised as a distinct group.
Tal Shales	Lower Tal Shales	Middle Ayarpatha Mall.	
Krol "Lime" (almost entirely dolomitic)	Upper Krol "Lime stone" or dolomite	Deopaths Part of Ayarpatha	Massive Limestone
Red Shales thin bands pink porous white	Red Shales with beds of pink dolomite containing Chert bands	China Sumita near Deopatha-China Col	
Krol Lime- (limestone, limestone calc shale)	Grey-green calcareous slates, slates and bands of dark blue non-dolomitic lime-stones	Woodstock-China path, China Cliffs, Depot Road.	Purple Slate series
Sandstone of 77°30')	Absent		
Krol pyritic carbonaceous shales=Blaini	Black pyritic bleaching carbonaceous slates with some purple slates	Power Pipe Line above Durgapur Kalakhan hill opposite Power House.	
1 boulder beds carbonaceous	not seen.	Almora Road near Cemetery.	
at Quart	Purple and white quartzites, purple slates	Lariakanta	

The chief difference between the two areas is that the Lower Krol Limestone of the Simla area becomes less calcareous towards the south-east, and, apart from distinct bands of limestone, such as those mapped by Middlemiss on China and Sherk-ka-Danda ceases to have the appearance of a limestone series. In actually however many of the slates on China are calcareous, and have the composition of marls. It may be pointed out that the limestone bands in the Lower Krol stage are non-dolomitic, whereas those in the Krol Red Shale stage, and the overlying "Massive Limestone" are mainly dolomitic containing as much as 41 percent of $Mg CO_3$.

2. Structure.

Naini Tal evidently occurs at the south-east end of one of the synclinal basins of Krol and Tal rocks which are arranged en echelon between Sirmur State and the Kumaun, throughout a distance of 150 miles. I have mapped four basins east of longitude $77^{\circ}30'$, and Naini Tal is probably situated on the south-east end of the fifth basin.

The detailed structure of Naini Tal is certainly very complex and cannot be determined without mapping a larger surrounding area, and further subdividing the two groups of rocks originally made by Middlemiss as has been done in Column 2 of the table given above. Moreover, one is suspicious of a series of quite vertical faults all meeting at a single point in the lake. I pointed out this feature to Heim and Gansser, who subsequently wrote:-

"The result of our rapid investigation within a few days showed us first that a larger part of the country than that indicated by Middlemiss is sliding or filled up with blocks of mountain slides, and that even Ayarpatha mountain, with its stratified southern limestone face, is generally broken up in such a way that it is impossible to design a correct tectonical section..... Although we found some blocks of 'trap-dyke' on Ayarpatha, neither the intensely folded and faulted Ayarpatha syncline of Middlemiss nor the ocb-web faults could be verified."

I agree with Heim and Gansser in believing that a larger area should be shown as slipped. I consider that the dolomite quarried south-east of Sukha Tal, and those of Handi Bandi hill have slipped and are not in situ. The Handi Bandi dolomite have possibly subsided vertically without much lateral movement on the underlying Krol Red Shales, which are easily lubricated and may have been squeezed out with resulting collapse of the overlying dolomites. The Sukha Tal dolomites, on the other hand, appear to have slipped laterally from the north side of the western slopes of the Ayarpatha.

As stated above, no adequate geological map of the area can be made without working centripetally inwards from beyond

the Sukha Tal and subdividing the formations further

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than was done by Middlemiss. The mapping of the probable Tal^h beds west of the lake may have an important bearing on deciding whether or not the lake is blocked by a landslip. I append a preliminary geological sketch on the scale of 1" = 1 mile, which makes no pretence at completeness or great accuracy, but is an advance on that produced by Middlemiss.

From the point of view of the present enquiry, we may note the curving of the Lower Krol slates and subordinate limestones round the Ayarpatha syncline, and the great thickness of these slates on China and Sher-ka-Danda as contrasted with their narrow outcrop west of the Ballia ravine. The dips of these slates and limestones, and the outcrops of the Krol Red Shales and dolomites extending from the Hallet War School westwards to Kumaun and Dufferin Lodges, indicate considerable duplication by faults which are probably inclined thrusts. It appears that the south east end of ^{the} Main Tal syncline is marked by independent packing up of slices of slates (like tiles on a roof) under the more massive and resistant upper Krol dolomites, as a consequence of torsional stresses during folding. There is also the possibility of an unconformable overlap of the dolomites over the slates towards the south west, a feature which is curiously present in several of the synclinal basins north-west of the Ganges.

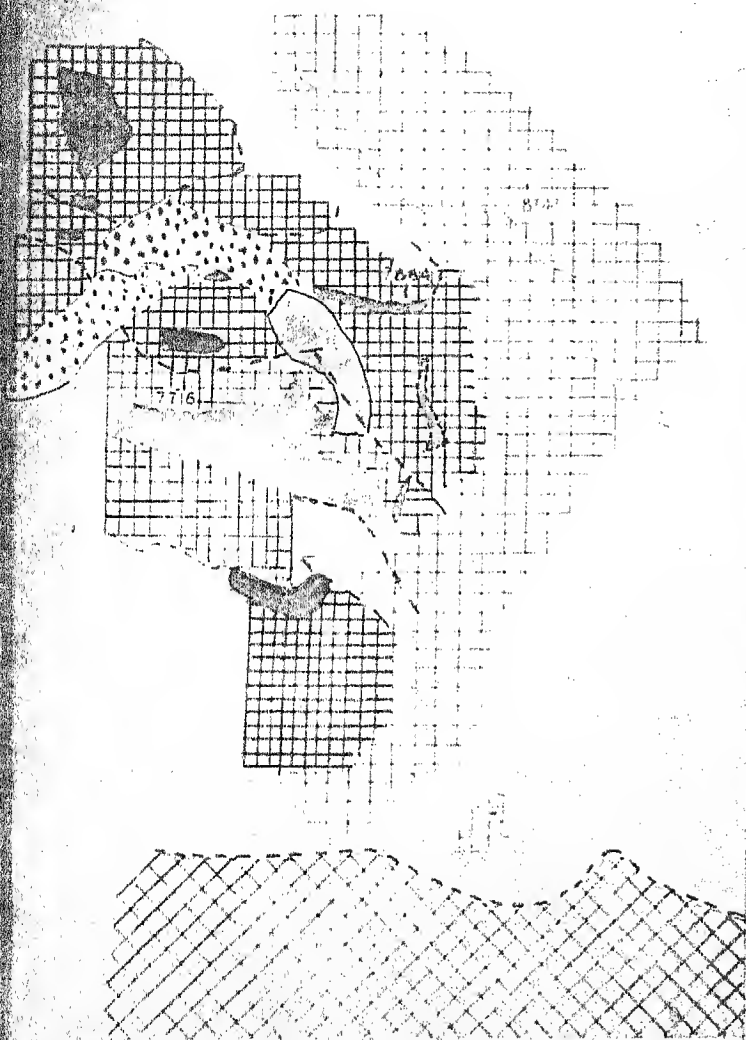
3. Quarrying of Limestone

One question, which Mr. Hatfield brought to my notice, is the extraction of boulders of dolomite at Patria, south west of the Woodstock Gorge, for calcining into lime. This extraction of boulders embedded in soil tends to cause instability of the soil and boulder overburden on the east face of Deopatha hill.

I suggested at the beginning of my visit that the limestone in the lower Krol Slates on the west side of China should be utilised....

utilised instead, partly for the purer lime which would be obtained from the non-dolomitic rocks and partly to eliminate possibility of slips east of Deopatha. Unfortunately, however, limestone dip towards the south-west and quarrying on the west face of China would lead to accidents by the slipping down of blocks along the bedding planes. A precaution that can be taken to see that only loose boulders of dolomite should be used for lime burning, ^{and} not those the removal of which would lead to slope instability. The workmen should be allowed to blast.

PROVISIONAL GEOLOGICAL MAP OF NAINI TAL





 Nahan


 Tal


 Upper Krol Dolomite

 Krol Red Shales

 Lower Krol Slates, calc slates and limestones

 Infra Krol-Blaini

 Naglhat

 Faults and Thrusts

29° 20'

79° 30'

0 1/2 1 2 Miles

III EXAMINATION OF BUILDING SITES.

Co-ordinates refer to grid reference numbers on the 6" Guide Map of Naini Tal.

1. North-west of Dereham House, (435:756)

The application is to build on a site 200 ft north-west of Dereham House. The ground slope is 41° , and although the rock is largely dolomite, the chances of instability arising from excavation are great. For every 50 feet cut into the hill, a retaining wall of $43\frac{1}{2}$ ft in height would be required. This site does not come within the Prohibited Area, but it should be condemned.

2. Miss Misra's site. (435:778)

The ground slope is 20° downwards from the site, and 30° above the site. The rocks are sandstones and shales, belonging probably to the Upper Tal stage, and dipping 60° north, across the slope. The site does not come within the Prohibited Area, but was condemned by a former Executive Engineer on grounds which are frivolous and invalid. The site is a good one, and building should be permitted on the lines laid down in section XIV.

3. Application of Mr. Pula Ram Shah (490:805).

This is adjacent to the Lake Mall Road and below Headingly. The ground slope is 23° - 25° . The slates are reasonably sound, and dip 50° - 60° N.N.W. The site is a good one. The only danger which can be anticipated is from the creep of the soil cap behind the site over the underlying slates. Springs issue from the junction of the soil cap with the slates.

4. Arya Samaj, (484:800)

On the banks of the Lake. No geological comment can be made as rocks are not visible, and the extent of the shelving talus under the lake is not known. Foundations should be constructed in the same manner as of the Library at present in the course of erection further to the north-west.

5. Mrs. Grant's Site, (501:787)

This site is in a narrow triangle of filled-in ground which slopes up steeply to the tennis court of Primrose Bungalow at an angle of 35° . Construction should not be allowed.

6. Suffolk Hall Cottage (509:761)

Ground Slope 23° : Slates dip 50° towards 340° , and are much and decomposed. Better slates occur north of the drain on the north side of the site. The old application was for a house on tennis court which is only 25 feet wide. This application was taken down, and a new one was submitted recently, on a site below the court now occupied by latrines. This site is definitely bad, since there is no rock present, and the filled-in ground is unstable. The earlier application is more valid provided the design of the building is approved by the Executive Engineer, and any filled in ground built put out from the tennis court on the south-west side is adequately prepared.

7. Castleton Site, (500:830)

Rai Bahadur J.S.Bisht has applied for permission to build a house between Castleton and the Middle China Mall. The ground slopes at 23° . Little rock is seen, but there is one exposure of weathered slates dipping 30° N.W. Building should be permitted subject to the conditions laid down in this report.

8. Between Jakhwal Sadan and Stoneleigh, (520:810)

Rai Bahadur J.S.Bisht has also enquired about the suitability of building between these two houses. The ground slopes at an angle of 32° . The apparent dip of the slates in the direction of ground slope is 20° , and the slates are weathered and much broken. Considerable erosion is taking place along a nala flowing between the two houses. This site should be condemned. Erosion of this should be stopped by lining. Slipping of the slates is well seen at the south-corner of Jakhwal Sadan - where a drain has been built for ever a year and water accumulating on the tennis court cannot be removed.

9. Shilpkar Sabha, (523:713)

The site proposed is in the Ballia Ravine below Talli Tal. The site had previously been turned down when it was proposed by the A r y a Samaj. There is no visible rock in situ in the neighbourhood, although boulders of dolomite are present. Most of the slope is made up of filled-in material which is loose and would not be a good foundations. A strong retaining wall would be required, as the motor road is only a short distance above the site. The site is not satisfactory, and should probably be condemned. An alternative site might be selected near Sukha Tal or along the Depot Road near the Ordinance Store, but I understand neither of these would be convenient to the members of the Sabha.

IV. RESERVOIR SITES.

In a project for the re-modelling and zoning of the Naini Tal water works prepared by Williams, Temple and Bartholomew, it is proposed to erect three reservoirs on the hills around Naini Tal. These are detailed below.

	Grid Reference on 6" map	Content Gallons	Cu. Ft.	Weight of water in tons.	T.W.L.	D.W.L.	Difference TWL-DWL	
the	310:729	12,000,000	1,930,000	54,000	7265	7239	26 ft.	Masonry
Ins- Bunga er-ka-	463:913	4,000,000	640,000	18,000	7434	7413	21	2 RC Tanks
o- ol.	196:913	1,000,000	160,000	4,500	7567	7550	17	Masonry

1. Ayarpatha Site.

The site is in a small east-west basin on the south side of Ayarpatha hill, which was once a valley, but has evidently been

been blocked to a depth of about 20 feet by debris.

On the south side of the basin there is an outcrop of massive dolerite, intruded as a sill amongst the probably Tal slates. On the north side of the valley there are micaceous slates, dipping north at low angles. The slates overlie massive Krol dolomite of the scarp face of Lands End. The site is 200 yards north of the scarp face.

The site is in my opinion quite safe. ✓

2. P.W.D. Inspection Bungalow Site.

It is proposed to erect two circular 2-million gallon reinforced concrete tanks, the centres of which will be 203 feet E 38° S and 230 feet E 60° S of the south-east corner of the P.W.D. Inspection Bungalow. The tanks are to have a diameter of 140 feet.

In spite of what is claimed by the consulting firm, the tank south-east of the Inspection Bungalow definitely lies astride the old crack line which was the subject of so much concern between 1860 and 1907. Indeed, the old Government house was demolished (except for the portion now standing as the P.W.D. Bungalow) because of the existence of this crack. Even though little has been heard about movements along this old main fissure for the last 35 years, it would clearly be most unwise to put a heavy tank, the water in which would weight 9,000 tons, on the very fissure which was considered as likely to be the line of fracture of a major slip. ✓

The slates in the vicinity of the bungalow dip at angles varying from 30° to 50° , averaging about 40° , towards the W.S.W. There is one exception, in the hillock east of the gully leading from the bungalow to the Chemical Examiner's Laboratory, where the true dip, ^{of the sealed} ~~simulating~~ bedding, planes is 80° S.S.E., while the cleavage dip, ~~simulating~~ bedding, is 45° west. But W.S.W. is the general direction of bedding dip of these slates.

The ridge strikes 297° ^{-117°}, the maximum slope facing Naini Tal being towards 207° . The angle of slope just below the P.W.D. Bungalow, as seen from plate I of Holland's 1896 report, varies from 40° , through 30° , 32° to 25° .

The apparent dip of the slates in the direction of maximum slope (270°) would average about 33° , which is about coincident with the average slope of the ground for some distance below the Bungalow. In Plate I of Holland's paper the average dip is shown as 27° , but this is a slight underestimate.

This is not a satisfactory condition for stability, unless the tank is placed well to the N.N.E. of the P.W.D. terrace and south face of the ridge, so that the resolved part of the pressure in the direction of the bedding and cleavage planes, due to the weight of the tank, is taken up by slates which will not be liable to slip down coincident with the face of the hill.

Both on account, therefore, of the condition of the dip of the slates in relation to the direction of ground slope, and of the existence of the old crack line, it is imperative in my opinion that any tank or tanks constructed on the ridge should be placed as far as possible on the northern side of the terrace, away from the crack line and the southern face potentially liable to slips. Construction should be confined to the area north of the E.S.E.-W.N.W. drain which runs east of the P.W.D. bungalow, and should avoid altogether the flat terrace which was formerly the site of the old Government House.

Taking the area N.N.E. of the drain referred to above, there is a distance of 230 feet from the drain to the northern scarp face, and 190 feet from the gully eastwards to the slopes dropping down to the St. Lee gorge. At least 30 feet should

should be left free from construction from both these faces, so that the rectangular limits for construction north of the drain and east of the gully are 200' x 160' or 32,000 sq.ft.

Unless, therefore, some of the ridge, west of the gully, on which the P.W.D. bungalow stands, is cut away, the limiting area for construction is 32,000 sq. ft. Since the ridge is one which has been subject to disturbance along the crack line old main fissure, it is necessary to reduce as far as possible the load per square foot of any reservoir constructed upon it. One may adopt an arbitrary figures of depth of 16 feet of water in the tank, equivalent to a load of 1,000 lbs. or 0.45 tons per sq. ft. Since 640,000 cu.ft. of water are required under the re-zoning scheme, it follows that the area of the reservoir should not be greater than $\frac{640,000}{16} = 40,000$ sq.ft. Consequently there is not enough room for the required reservoir unless a portion of the hill west of the gully and adjacent to the P.W.D. Bungalow is levelled off. As pointed out by the consulting engineers, the reservoirs will not represent entirely an extra load on the ridge, because their additional weight will be partially offset by the removal of the hillock and a portion of the P.W.D. ridge.

3. Deopatha-China Site.

The proposed site is on the col between Deopatha and China hills, on the west side of the bridge path leading north from the Forest Chauki to China, and crosses the 7500 contour.

The rocks of the cliffs on the east side of the col belong to the Lower Krol and Krol Red Shale stages, and are folded into an anticline, the dips at the chauki being south-west and, on the east side of the path, north and N.N.E. There is also probably a fault running along the axis of the anticline and through the col.

The hillside west of the bridge path slopes westwards

at.....

at a gentle angle of about 5° . There is no sign of rock in it but only a thick sticky greasy clay containing fragments of slates and limestone. This clay is not a good foundation for a reservoir, particularly if likely to be wetted by percolation from the bottom, as there will be a tendency for it to ooze out under pressure towards the west. It will be necessary completely to excavate away the clay and reach the slates and shales below.

V. SEWAGE SETTLING TANK AND ROUGHING FILTER.

The Superintending Engineer, Public Health Department, requires a site for a settling tank and roughing filter in the Ballia ravine and as close as possible to Naini Tal.

The tank is to have a capacity of 50,000 gallons or 8,000 cu. ft., and is to be 6 feet in depth. The area involved is therefore 1,330 sq. ft., and the linear dimensions may be taken to be 6' x 25' x 53'. The dimensions of the roughing filter are not known.

Neither the Executive Engineer nor I were particularly sanguine about being able to find a site which would not endanger the sides of the Ballia ravine. However, a site was located on the right (west) bank of the Ballia, in the angle between the Ballia and the Fairy Hall drain, at a height of approximately 5850 feet (Grid. Ref. 545:690). This is the site of an old bone dump enclosure below the slaughter houses. The dump is no longer used since the bones are now scattered higher up the ridge. It was raining so severely at the time of a joint inspection by Mr. Hatfield, Mr. Bhola Dutt and myself that actual measurements were not taken, but the bone dump enclosure is at least 100 feet along and 25 feet wide, and should be able to accommodate both the settling tank and the roughing....

roughing filter. This enclosure lies on slate debris, but there is slate rock in situ just below, which dips north-westwards into the hill. These slates are reasonably tough and are suitable as a foundation for these structures, provided a minimum of 30 feet of rock is kept as a free edge. No cutting into the hill at the back will be necessary if the dimensions of the tank are, as given above, 6' x 25' x 53', but there should be a scree trap at the back.

The settling tank and roughing filter should be on the alignment of their long axes, along the contours and not across them.

VI. SAFETY OF THE POWER PIPE LINE.

In the memorandum, dated 1.7.42, and issued by the Chairman of the Municipal Board, I was asked to state whether or not a guarantee could be given that the Power Pipe Line would remain intact during the next five or six years. It is naturally impossible for me to give such a guarantee, and the Committee agreed during the meeting of the 8th July, 1942, that it would be advisable to construct a stand-by power station as soon as possible at Kathgodam.

The greater part of the recommendations suggested by Coulson in his 1939 Report on the Safety of the Power Pipe Line have been carried out. Recommendation No.7 is in my opinion unnecessary, since the hill side is composed of slate which, apart from a major landslip, will not fall as large boulders but as a loose scree.

Coulson has already given a detailed account of the geological condition of the pipe line. The only portion of the line which seems at present liable to dislocation is between anchor block 93 and 107, along the 5,800 contour.

Along....

Along this stretch of the pipe line the soil cap, mixed with weathered fragments of slate, is undergoing surface creep from the west side of the Gangipur 5600 flat. The ground slope as measured in one place by an Abney Level is 35° , but as measured from the contours of the 10" to one mile map is seen to vary from 36° to 41° . This gradient is equal to or greater than the angle of repose of dry slate scree, and it is difficult to suggest any remedial measure apart from an intensification of the drainage of the slope between anchor block 93 and 107. It is unlikely that retaining walls would be of any use, as these would probably sink slowly with the hill side which they are supposed to protect.

Tell-tales placed on the anchor blocks show only minor hair cracks, but nothing to indicate abnormal movements. Theodolite observations have also indicated no movement during the last three years.

VII. EXAMINATION OF UNSTABLE AREAS.

1. Fine view. *(Dynamometer)*

Bulges have recently developed in the retaining walls of both the roads below Fine View, and also at the back of Fine View. There has been a slight subsidence of the lawn at Strawberry Hall. As Mr. Hatfield pointed out, the individual symptoms might not, alone, have given rise to suspicion, but collectively they suggest some measure of instability of the whole hill side below Fine View.

The slope of the ground is shown in Holland's section No. 14 (1896 report) to vary through the following angles:- 14° , 20° , 29° , 40° , 50° . The average slope below Fine View is about 36° . The dip of the slates is 30° N.N.E., less by 6° than the slope of the ground and in the same direction.

This....

This is a most unsound geological condition, and the lowest 200 feet of the hillside must be considered as unstable.

Nothing much can be done about this, apart from improving the drainage wherever possible. The inhabitants of Fine View, Misra Lodge and Strawberry Hall should be warned that they live in these houses at their own risk.

2. Killarney

The slip which Holland predicted in 1892 would occur below East Laggan (close to the modern Killarney), took place on the 31st July, 1938, 46 years after the warning. Warning signs began to develop on July 25th, when a few boulders were dislodged and cracks appeared across the hill below the East Laggan Road. Prompt attention was paid by to these warnings by the Executive Engineer, and the area was barricaded off. The slip breached the East Laggan and Middle Ayarpatha roads for a length of 100 feet, and is 230 feet in height.

Holland's section No. 16 illustrates the structure as it was evidently then disclosed. In actuality there is a sharp syncline in the sandstones, quartzites and shales (probably Upper Tal), the axis of which runs N.W.-S.E. through Killarney. The scar left by the landslip shows south-west dipping sandstones and shales, and similar dips are seen just east of Edwinstowe Cottage and at the foot of the landslip on the west side. These sandstones and shales with their underlying dolomites, are much shattered and jointed, evidently along the axial plane of the synclinal fold, and the slip has followed fairly closely to this plane, although most of it was in south-west dipping rocks.

There is still much loose rock in a precarious condition which has still to come down and it would be unwise to construct the road across the slip until either the boulders fall of their own accord or they are dislodged with explosives.

The.....

The Killarney area is unsound geologically, but it may be years before any other major slip occurs. It seems an unnecessary precaution to forbid the construction of a road across this area, though it should preferably be aligned on the south side of the flat terrace which was formerly occupied by East Laggan.

I was not able to complete my examination of the area below the Wellesley Girls' School. Some of the 1940 tell-tales and a few of the 1941 tell-tales show small cracks, but nothing of a serious nature.

A minor slip occurred in July, 1942, down a nala below Edwinstowe Cottage from the Middle Ayarpatha Mall to the East Laggan Road. This nala must be lined and made pucca.

3. Purbeck Lodge. (*Ayarpatha*)

In 1942 minor slips have developed below Purbeck Lodge and the terrace in front of the house has been fissured. The bay window has subsided away from the building, and there are cracks in the south wall of the house.

So far as I could see, the slips are confined to the soil cap, and do not occur in the dolomite, shales and quartzite at the side and back of the house. The slope of the hillside below Purbeck Lodge is 34° , which is close to the critical angle of repose of loose slate and soil.

Only a strong retaining wall, founded on rock, will prevent further slips, and the collapse of the terrace.

Purbeck Lodge is a good example of a building which is located on a steep slope, and rests partly on terrace fill. It is in the so-called Safe Area, but is less safe than certain localities in the Prohibited Area.

4. Depot Road.

I was unable to make a detailed examination of this road. The greater part of this road is in Lower Krol slates and calcareous shales dipping at gentle angles towards the west. The slips which have occurred both along this road and the Almora road above appear to be along joint planes.

Sections of the hillside above and below the Depot Road are given in Nos 20-24 of Holland.

	<u>Average slope</u>
Section 20	32°
21	34°
22	35°
23	37°
24	28°

In places the slope is as much as 60°. Such slopes inevitably imply instability in the case of rocks as jointed as the local Lower Krol slates.

There is a zone of subsidence running from Fern Hill downwards to the Depot Road, but this is only one of many alignments on this hill side which is capable of slipping.

The drainage of this side in the Cantonment area needs better attention, and should be done under the supervision of the P.W.D. Executive Engineer, as recommended at the Committee meeting held on the 3rd July, 1942. No drainage should be allowed to flow from the hillside by Resemount Villa onto the southern face of the hill above the Almora Road. Many of the drains have already been diverted but one was noticed which debouches directly on to the cliff side and in times of flood would add materially to the erosion.

Coulson remarked that he would hate to drive a heavy motor lorry over certain parts of the Depot Road, knowing its condition of geological instability. That is true enough, but the Army, by virtue of its profession, is accustomed to far

greater....

greater risks than any which would be incurred along the Depot Road, and, if it is convenient or necessary in war time for the Military to take lorries over their own roads, I ^{should} ~~should~~ not be inclined to stop them. There are geologically far worse stretches on the Burma-China road, but this road was used daily and as a matter of course. If Safety First is to be a motto, the contrary Voice out of the Whirlwind should also be listened to, (Book of Job).

VIII. ADIT DRAINAGE.

The question of adit drainage has been raised again in the Memorandum of the Chairman of the Municipal Board dated 1.7.42. It was discussed at length by Holland (1896 report paras. 110-115) and was considered by the 1907 Committee (Paras 30, 52(24)). It is a matter open to much difference of opinion.

Five adits were driven in 1896, and yielded in 1898 after 14½ inches of rainfall the following quantities of water in gallons per minute:- 13, 14, 13, 164 and 246. One adit which Mr. McDonald, the D.F.O., showed me close to Spring Cottage, was yielding at an eye estimate about 10,000 gallons per hour. This adit is said to be perennial.

Underground drainage systems have been employed in America, particularly to dehydrate definite bands of clay upon which land has slipped. In one instance west of Los Angeles, clay has actually been dehydrated and rendered less plastic by blowing hot air into a drift. Such measures are particularly effective in treating clays holding much physically absorbed water which renders them plastic. The more indurated the rock, however, the less will its physical condition affect the stability of hill sides and the more important becomes the tectonic disposition of its divisional planes. Adit drainage will...

will not affect the physical condition of slates, which in the process of cleavage and compaction has lost almost all the water except that chemically combined in the form of hydrated aluminium silicates.

In Naini Tal there are no plastic horizons (except locally the Krol Red Shales) to act as planes of lubrication and slipping. The slips occur on account of the unstable disposition of the divisional planes with reference to the ground slope. Adit drainage in Naini Tal will merely assist the springs to relieve the slates of the ground water held in the divisional planes. The volume of water held at any given moment in these divisional planes would be constant whether the water is escaping into an adit with a perennial flow or is static and without a ready outlet, but the pressure exerted by the water would be less in the case of a free outflow. The water thus held in slates may be a contributory cause in the formation of landslips but major landslips in slates and other indurated and metamorphic rocks are to a large extent ~~by the water~~ due to their structure, and only to a minor degree to their ground water content.

Consequently adit drainage in slates, as distinct from weathered more clayey soil-cap, is not likely to affect the stability of hill sides very profoundly, and the cost of driving deep adits into the unweathered slates would not be justified.

Dehydration of soil-cap, on the other hand, would be a valuable procedure if practicable. It is only necessary on the steeper hill sides with a gradient greater than 1:2 ($26\frac{1}{2}^{\circ}$), and it is precisely on such steep hill sides that the thickness of the soil cap in a horizontal adit direction is likely to be small. Adits would be of less use than a system of inclined perforated pipes buried in the soil cap and

and leading out into pucca drains. The cost of these would be prohibitive, and it appears to me best to continue annual improvements in the surface run-off drains, and thereby to diminish as far as possible the access of water to the soil-ca

IX. THEODOLITE OBSERVATIONS AND STEEL-TAPE MEASUREMENTS.

The following data have been kindly supplied by the Executive Engineer from the records of the Public Works Department and the Municipal Board Register of Observations. Only those pillars and pegs actually showing movement are listed below. The table numbers are those recorded in the Annual Reports of the P.W.D. Coulson has listed the movements up to and including the year 1938.

	Rainfall in inches	Percent Run-off
1937	124.08	78
1938	112.26	82
1939	70.00	65
1940	83.54	64
1941	90.15	—
1942 up to 20.7.42	100	—

The average rainfall in Naini Tal between 1895 and 1938 was 106.09 inches. The ^{mean} rainfall for the short period 1939-1941 is 81.23 inches, which is very low. It should be borne in mind, therefore, when considering the results of the theodolite observations and other measurements, that, in so far as there is a connection between the movement of the hillside and the rainfall, observations are likely to be abnormal.

Table IIIa.

Annual Movement along main fissure of Kalakhan Hill
measured by steel tape between pegs, in feet—

1939	1940	1941
N11	peg 3 H 0.04 ft.	N11
	4 H 0.32	
	V 0.04	
	7 V 0.04	
	8 H 0.03	

Table IIIB

Annual Movement along Depot Road, measured by steel tape between pags, in feet.

1939	1940	1941
N11	Peg 1 H 0.02 ft 2 V 0.05	N11

Table IIIC

Annual Movement between pillars on Kalakhan Hill, observed by theodolite from Bleak House Observatory, in feet.

1939	1940	1941
N11	A3 H 0.31 ft V 0.24 B3 H 0.31 C3 H 0.60 V 0.23 D3 V 0.36 F V 0.43 P2 V 0.12	N11

Table IV

Movement in inches of pillars of the St.Loe and Edgehill Depressions.

1939	1940	1941
St.Loe Pillars N11	N11	N11
Edgehill Pillars		
5 0.12"		
7 0.12"		
8 0.12"		
9 0.24	↑	↑
10 0.12	N11	N11

Table Va.

Pillars on Sher-ka-Danda recorded by theodolite from Jesmond Villa and Brookhill.

1938-1941 incl.

No movement recorded.

Table Vb

Movement of Pillars on Sher-ka-Danda Hill observed by theodolite from Tennochy. These observations include pillars No. 9-14 erected on the hillside from the Hallet War School to Jakhwal Sadan in 1939.

1939-1941 incl.

No movement recorded.

Table.....

Table Vc

Movement of pillars on main cracks of Sher-ka-Danda Hill observed by steel tape measurement.

1939-1941 incl. No movement recorded.

Table Via

Movement of pillars on Charta Hill, including pillar 22 on Gangipur Spur, observed by theodolite.

1939-1941 incl. Nil

Table Viib

Movement of 4 pairs of pillars along fissures in the Hallet War School recorded by steel-tape measurement

1939-1941 incl. No movement recorded.

Municipal Board Register of Observations of the Hydro-Electric Power Pipe Line and its surroundings on Gangipur Hill. Movements recorded in 1942 in incl

Pillars Nil

Pages 11 + 12 3/8"

15 + 16 2/8"

It is seen that apart from Kalakhan Hill, which has been subject to great movements for many years (Table IIIa,c) there have been no movements of any importance during the period 1939-1941 inclusive. As stated above, these years have had abnormally low rainfall, and the absence of movements may be related to this failure of rain.

With regard to the area of Sher-ka-Danda Hill south-east of the St. Loe gorge, it is essential to wait until there have been two consecutive years of high rainfall, or two years of high rainfall in three consecutive years, before any revision of the existing regulations can be undertaken.

PART II.

X. GENERAL CONSIDERATIONS.

1. Introduction.

We come now to the general question of the stability of these hill sides. This question has been thrashed out by successive generations of engineers and geologists, and reading through the reports indicates that there has at times been a considerable amount of disagreement. This may be a cause for jubilation amongst those who consider that the contrary opinion of specialists neutralise and thereby vitiate any protective measures that it has been thought necessary to take so as to assist the stability of these hill sides. It has indeed been held that the whole question has been made unnecessarily complicated, and there is a tendency to regard the precautions hitherto taken as designed to frustrate the public, and prevent owners of property from constructing residences haphazard over the hill sides. As in the case of earthquakes, memories are short, and, given its own way, the public tends to construct regardless of past warnings. It may be pointed out that in California, New Zealand, Italy and Japan there are building codes which compel the public to construct houses according to a definite set of rules. This has not yet come to pass in India as far as earthquakes are concerned, but Naini Tal is probably the first town in India to adopt any regulations on the basis of hill side stability. I have no figures of the actual cost of protective measures incurred during the last 60 years, but it must be of the order of one crore of rupees, and there are now 90 miles of pucca drains around the town. This is a record which must be hard to exceed in any part of the world, and while no guess even can be made as to what the results would have been without any protective measures, it is unquestionable that they were necessary and have been a potent factor in rendering the hillsides less dangerous.

The...

The onus of the decisions taken falls on the engineers and the geologist called in temporarily for report. In effect, however, it is the Executive Engineer who not only carries out the recommendations, but who, since the geologist is peripatetic and ephemeral, also has the responsibility of making decisions concerning building sites. During the last 60 years a considerable literature has grown up from the joint deliberations of engineers and geologists, and the engineers have inevitably acquired some of the general geological principles laid down formerly by Middlemiss and Holland. While it is very desirable to continue calling in geological opinion on the major issues involved, and also more frequently, if available, to examine particular sites over which there may be some dispute, it is erroneous to consider the engineers simply as a layman in these matters, and as a consequence to ignore or over-rule their opinions. As an example, I may cite the wise precautionary measures taken by the Executive Engineer who recognised in 1939 the warning signs of the Killarney Landslip.

2. Factors relating to Hillside Stability.

Holland has enumerated most of the factors concerning the stability of the hillsides at Naini Tal in section IV of his 1896 report, and Holland's account has been summarised by Coulson in his 1939 report on the Alignment of the Power Pipe Line. The principal factors are:-

- (1) The composition of the rocks
- (2) Their state of preservation.
- (3) The direction and inclination of dip and other divisional planes.
- (4) The variations in sub-aerial conditions to which they are exposed.
- (5) The occurrence of earthquake shocks.

In addition it is necessary to consider the effects of building operations. Excavation on hill sides involves cutting.....

cutting into the hill slopes and filling out portion in the tip-heap manner so as to create level terraces of sufficient width upon which to construct houses, tennis courts, play grounds, etc. Thus, assuming a ground slope of 30° (gradient 1:1.73):- to cut into the rock so as to make a terrace 50 ft. wide, situated entirely on rock, would necessitate a retaining wall at the back 28.9 ft. in height, involving much masonry and expenditure in excavation. If the hill side is cut so that the retaining wall is not more than 15 ft. in height, then only 26 feet of the terrace would be founded on rock, and the remaining 24 feet must be made of rock-fill and earth; roughly half the width of the terrace.

Such filled out portions, or made-up ground, are seldom fully compacted at the time of construction of buildings upon them, and volume shrinkage almost certainly takes place in subsequent years, which may be masked by alternate drying and wetting in monsoon climate. Once constructed it is impossible to know satisfactorily the contours of the actual rock face upon which the made-up ground rests.

Moreover, contractors vary in the diligence with which building work is carried out.

In addition therefore to the uncertainties of actual geological conditions, there are superimposed uncertainties about the nature of the filled in ground, and the conscientiousness of the builders.

It is possible that, as a consequence of the known instability of the hill sides around Naini Tal, every symptom of cracking in grounds and buildings is attributed to the single cause of rock masses tending to descend under the influence of gravity. This may not be so in actuality, as even in flat regions it is frequently found that symptoms arise which simulate those experienced on hill sides and

in.....

in earthquake shocks. Apart from the Henslowe Committee of 1883 and J.B.Henslowe's report of 1889, other investigations of the Hillside problem in Naini Tal do not appear to have taken cognizance of this factor. A few of these instances will now be cited.

3. Cracks in grounds and buildings in flat regions.

Cantonment, Benares¹

In August 1934 I was asked to advise about the existence of ground fissures and severe cracks to buildings which had developed in the flat area of the Cantonment at Benares. The largest fissure was 440 yards in length and at one time 14 feet in depth. The military authorities were considering removing the whole cantonment to a new site. While the Bihar-Nepal earthquake of 1934 may have intensified the cracks to buildings, it is significant that the ground fissures and building cracks had begun to appear before 1930, and no fissures were formed actually by the earthquake. The conclusion to which I came was that the made ground (brick bats, ashes and clay), sometimes over 20 feet deep, is undergoing a gradual process of compaction, the volumetric change being proportional to the variable thickness of the made ground. The cantonments are still standing, and no trouble has been recently experienced.

Kulti, Bengal. Since 1917, the southern slopes of the gentle hill occupied by the residential quarters of the Indian Iron and Steel Company, Kulti, have been subject to ground cracks and the quarters erected upon them have suffered a considerable amount of damage. In some cases the cracks were so serious that buildings had to be demolished. The gradient of the hillside is about 1:45 (angle of $1^{\circ}16'$), so that there is no question of instability arising on account of a dangerous

hill slope. The quarters are built upon rice paddy fields, and it seems clear that the soil of these old fields is a cover of variable thickness lying upon shales. The foundations of the buildings are in some cases extremely shallow, and there is little doubt that the buildings have suffered from volumetric changes in the soil in the same manner as those at Benares.

University Baptist Church, Austin. Texas.

Legget states that the foundations of this church were built as concrete walls carried to rock, surrounding a 6-ft. layer of decomposed shale under the building proper. Owing to an increase in the moisture content of the clay it expanded vertically by as much as 4 inches, lifting the church building by breaking concrete footing slabs, the expansive force of the clay overcoming the tensile strength of the concrete footing wall.

Winnipeg.

Legget shows that numerous buildings in Winnipeg are cracked on account of settlement due to dehydration of the clay sub-soil, a reverse process to that which took place at Austin.

I have cited these instances not in any way to belittle or ignore the symptoms which may be indicative of gravity instability, but to show that the possible presence of other factors, beside that of actual hill-side instability, greatly adds to the difficulty of a proper understanding and solution of the problem at Naini Tal. It is unfortunately true that different causes may give rise to very similar effects. Thus earthquakes, ground hydration and dehydration, differential compaction, and incipient land-slipping may all give rise to ground fissures and cracks in buildings.

4. Bedding. Cleavage and Joints.

Returning now to Holland's five points, a slight discussion

discussion of these is necessary, particularly with regard to his third point, on the direction and inclination of the dip and ~~xxx~~ other divisional planes. This had previously been discussed by Middlemiss, but was elaborated by Holland.

In Holland's illuminating sections of the Naini Tal hill sides the planes of dip are shown as straight lines for convenience of discussion. In actuality, however, the dips are often variable in magnitude from yard to yard, and even the direction of dip in any particular localised region is liable to change over a small range of the compass. An average dip calculated from several readings down a hill side may be misleading if the extremes of dip, from which the average is obtained, show markedly differing relationships to the actual ground slope.

Whereas, also, Holland often emphasised the abundance of cleavage and joint planes (para.91, sub.para.3) these additional planes of division are not represented in his sections, in which the single factor of bedding dip alone is illustrated. It frequently happens that the dip of the bedding planes may be such as to suggest stability with reference to the hill side, but that this satisfactory condition is vitiated by joint and cleavage planes, and slips may and do occur in spite of the sound dip. Examples are seen in the slips along the Depot Road, and the Kalakhan area.

In some cases it proves difficult in fine-grained homogeneous rocks of the clay-slate type, without intervening bands of limestone or quartzite, to distinguish the bedding planes, although close inspection may show that the bedding is demarcated by slight differences in colour. In several places along Sher-ka-panda, such as immediately south-east of the south-east end of Laidlaw Hall, and in one of the hillocks near the R. D. bungalow, the true bedding planes are sealed and....

and are not planes along which division of the slates takes place. What appears from a distance to be the bedding, and is in fact the principal plane of division, is the cleavage and not the bedding. Where the bedding planes are locally oblique to the general direction of bedding dip, cleavage often tends to conform to the general dip direction and mimics bedding. In other cases, the bedding planes remain planes of division, and the cleavage is inclined to them, affording an extra plane of division (south face of China). Finally, joints occur, along planes inclined both to the bedding and the cleavage.

These facts render the assessment of stability extremely hard, and less certain perhaps than might be suggested by the geometrical sections given in Holland's report. The great service rendered by Middlemiss was in introducing the primary conditions of instability, and by Holland in emphasising the relationship between the true dips of the bedding planes, and the apparent dips with reference to the direction of maximum slope, and also in pointing out the effect of erosion by ravines descending the hillsides. In addition to these facts, however, the existence of cleavage and joint planes must be taken into account, since these modify conclusions drawn solely with regard to the bedding planes. Moreover, it is necessary to bear in mind the possible existence of other factors, besides that of gravity, in creating symptoms generally regarded at Naini Tal as occasioned solely by gravity slipping.

XI. THE FISSURES ON SHEER-KA-DANDA

1. Historical Summary 1880-1937

At the time of my visit in 1942 there were no open cracks or fissures which could be examined, although slight subsidence....

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subsidence in the terraces of the Hallet War School (Philander Smith College) were still faintly discernible. Since it is the existence of these cracks which is the primary reason for regarding the hill sides as liable to serious slips, it has been though necessary briefly to review the opinions expressed concerning them, even at the risk of repeating portions of previously published reports, such as section III, p.5 of Coulson's report on the Safety of Certain Areas in Naini Tal (1939). Dr. Coulson's summaries were somewhat *lengthy* and not all the matter contained in them is relevant to the problem selected here for discussion.

R.D. Oldham: 1880.

In 1880 Oldham reported on landslip of that year which was responsible for the death of 193 people and the destruction of numerous houses. He attributed the landslip to the sudden collapse of a mass of debris of weathered slates which had previously accumulated and had been gradually descending on a surface of slates.

Henslowe Committee: 1883.

This Committee enquired into the condition of the then Government House, in which had appeared cracks. Two members of the Committee were of the opinion that the unequal consistency of the sub-soil under the foundations had tended to increase the cracks in the building, and all the members were agreed that the longitudinal cracks of the hill were consequent on the general disturbance of the hill during the cyclone of 1880.

By 1889 subsidence had been found to occur on the Government House ridge along a distinct line, a considerable portion of which was stated to be in rock and not solely in soil cap. Oldham considered that the cause and the nature of....

of the subsidence were obscure. The subsidence was found to begin a month or so after the cessation of the rains.

J.B.Henslowe: 1889.

Henslowe referred to the fissure under Government House as a distinct separation through the axis of the hill. The fissure was traced from Government House through St.Cloud to Snow View. His view was that the cracks were due to shrinkage of the soil cap as a consequence of dessication, the underlying rock not being affected.

F.O.Cortel: 1895.

Cortel described the movement which had taken place along the larger horizontal cracks between 1890 and 1894. A trench dug on the west side of Government House touched solid limestone & rock in which fissures 9" in width were exposed. It may be pointed out that fissures in limestones are generally the result of chemical solution along joint planes, and those in question cannot without more data, now impossible to obtain, be regarded as necessarily indicative of incipient fracturing of the rock and landslip movement.

Oldham: 1895.

Oldham considered that as a consequence of the "very rapid development" of the fissuring since he had last reported in 1889, a further landslip could not be deferred for many more years. He was supported by Griesbach, who could not say, however, whether or not the catastrophe would occur within a measurable time.

Beresford dissented from Oldham's view, remarking that there were no records to show that the cracks had increased since 1889. Here we have opposite conclusions drawn from presumably the same evidence.

Holland: 1896.

In 1896 came the detailed report of Holland. With regard to.

to the cracks on the Government House spur, Holland's conclusions may be summarised as follows:-

Ground Slope.	top	200 ft.	34°
	middle	600 ft.	30°
	lowest	200 ft.	20°

Dips of slates

	Magnitude of dip	Direction of dip	Direction of ground slope	Diver- gence of dip from ground slope	Apparent dips
Upper Bulge	30°	240°	225°	15°	28°
Lower Bulge	40°	247½°	225°	22½°	37½°
Surface gradient under G.H.			34°		
Apparent dip under G.H.			28°	(really 29°)	
Therefore wedge 34° - 28°		=	6°	(really 5°)	

"There is, therefore, a moveable mass of strata under Government House, which is in the form of a 6° wedge, having a length of 400 feet. It is the gradual creep of this wedge.....which produced the cracks parallel to the strike of the strata through Government House, and I should expect that the large fissure known to exist under Government House extends vertically down only to this gliding plane, which cannot be more than about 50 feet below the foundation of the house." (Holland 1896) Report. para.120, p. 40).

Holland remarked that serious landslips generally occur near the base of slate hills, and seldom arise more than half way up, as in fact happened in the 1867 and 1880 landslips in Naini Tal. Oldham sounded a note of warning, pointing out that landslips occasionally do start from the crests of ridges 1907 Committee.

Ten years later, the 1907 Committee, under the Chairmanship of C.H.Berthoud, showed that in the years when rainfall was considerable (1901, 1904 and 1906) a correspondingly large movement was evident in the Sher-ka-Danda fissure.

Discussing....

Discussing the movements of the previous 12 years, the Committee states (p.18) :-

"The figures do not disclose any tendency for the movement to become worse and the Committee, though unable to fully understand the cause of the movement, are of opinion that the stability of the hill as a whole is not at present affected thereby."

It may be remarked that no abnormal movements were observed in 1905 as a result of the Kangra earthquake of 44.05. Naini Tal came within isoseismal $6\frac{1}{2}$.

A.L.Coulson: 1927.

In 1927, 20 years after the previous enquiry, Coulson remarked on the undoubted annual movement taking place on practically all the spurs, but makes no special comment on the stability of Sher-ka-Danda.

1937 Committee.

There was no geologist on this Committee.

2. Cracks and Subsidence South-east of the St. Loe Gorge.

M.B.Hatfield: 1938.

By 1938 we cease to hear of the old fissure between the St. Loe Gorge and Snow View. A new issue is raised in the presence of cracks in the Philander Smith College (now the Hallet War School), and fissures in the compound.

M.B.Hatfield gives a detailed account of the cracks appearing in Laidlaw Hall, which had been constructed in 1928. The cracks in the building began to appear in 1930, two years after construction. After the Bihar-Nepal earthquake of 1934, part of the building sank 10 inches as a consequence of ground subsidence on the west side. The fissures figured by Mr. Hatfield are:-

- (1) Oak Ridge: W.N.W.-E.S.E.
- (2) Oak Openings: N.W.-S.E.
- (3) Dormitory: N.N.W.-S.S.E.
- (4) Laidlaw Hall: N.W.-S.E.
- (5) Playground: N.N.W.-S.S.E.

M.B.Hatfield..

Mr

M.B. Hatfield puts forward the alternative view that the subsidence may be local, and that, on the other hand, it may be an extension of the old main fissure which ran from Snow View to the Old Government House (now P.W.D. bungalow).

A.L. Coulson: 1939.

In 1939 Dr. Coulson published two detailed reports, in one of which (Report on the Safety of Certain Areas in Haini Tal, there is a lengthy account of the whole problem of Sher-ka-Kanda; Sections V and VI, pp.19-23.

Coulson points out (pp.21,31) that the dips of the slates by the Hallet War School are 30° W.N.W. and that the cracks which appeared in the School grounds run N.W.-S.E. and N.N.E.-S.S.W. This latter alignment is evidently a misprint, because the actual direction of the fissures in the Playground is N.N.W.-S.S.E. He states that the directions of the fissures are approximately along the direction of strike of the slates and shales, (pp.21,30,31). This conclusion is, however, incorrect, because a dip of 30° W.N.W. implies a strike of N.N.E.-S.S.W., whereas the fissures run N.W.-S.E. to N.N.W.-S.S.E., the divergence in compass angle between fissures and strike being from 45° to $67\frac{1}{2}^{\circ}$.

This is an important point, because it is evident that, in so far as the fissures may have extended down to the slates, they do not follow the strike and run down as planes parallel to the bedding planes, (as was concluded by Holland for the old fissure west of St. Loe Gorge) but must be coincident joint planes. Coulson states that the new fissuring is:-

"Not just mere surface soil cap movement, but actual fissuring of the underlying rocks. Its direction is mainly parallel to the strike of the rocks and there are at least three main fissures, more or less parallel in direction and trending south-east or S.S.E. One cannot of course give the actual depth of these fissures, but I should imagine that they are of the same depth, or slightly less, than that of the old fissure."

by Holland for the old main fissure of Sher-ka-Danda, i.e., 80 feet." (pp.30,31).

Coulson considered that whereasthe old main fissure has gradually healed up, under the action taken by the engineers, the condition of Sher-ka-Danda hill south-east of the St.Loe Gorge has definitely worsened, and that it would only be a matter of time before majorslips would occur in the region if no steps were taken to rectify the existing state of the drainage.

The whole basis of Coulson's ~~axxx~~ argument depends on his interpretation of the fissuring which has developed east of the St.Loe Gorge since 1938 (and probably since 1930). It is important therefore to consider this relationship between the strike of the slates and the direction of fissuring, for Coulson was clearly influenced by Holland's earlier account of the old fissure, which was formed, Holland stated, by the creep of the 6° - wedge parallel to the strike. In the case of the old fissure there was indeed much closer parallelism between the alignment of the fissure and the direction of strike of the slates. In the case of the hillside east of the St. Loe Gorge, however, the direction of the fissures is divergent from the strike of the slates by angles varying from 45° to $67\frac{1}{2}^{\circ}$, and the comparison with the old fissure is by no means exact. Jointing in these slates is often marked, but it is not possible to speak of "master joints", persistent in direction and capable of taking over the functions of the bedding planes. Cracks along the joints are perfectly possible, and major slips along curved planes oblique to the bedding do occur, as in the case of the 1889 slip on Kalakhan hill. But with the little definite evidence which we have concerning these new fissures, it is not justifiable on the basis of a comparison with the old one (which now proves not to be exact), to assume that the danger is necessarily as great as was once considered to prevail west of the St.Loe Gorge.

The direction of maximum ground slope below the Hallet War School is 55° - 235° , or only $32\frac{1}{2}^{\circ}$ divergent from the local strike of the slates. With an average dip of 30° W.N.W., (Strike N.N.E.-S.S.W.) the apparent dip of the slates in the direction of maximum slope is only 17° , an inclination along which the resultant of the vertical force of gravity is reasonably small, viz., 0.29 g., though not negligible. Provided, therefore, that erosion of the slates by lateral talus descending down the slope of the ridge is prevented, there should not be much danger of slipping below the Hallet War School along the bedding planes, although the chance of slipping cannot be regarded as non-existent.

J.B.Auden:1942.

My own visit to Naini Tal was four years after the trouble in the Hallet War School had become pronounced. The subsidence in the terrace west of the dormitory is almost certainly in the filled-in ground of the terrace. The fissure which ran through the Laidlaw Hall was diverted at the southeast corner of the hall from its N.W.-S.E. direction by slates cropping out on the terrace near this corner, and then assumed a N.N.W.-S.S.E. direction, to the Sportsfield, avoiding through the slates which crop out along the eastern side of the field.¹

There is no doubt whatsoever that most of the Sportsfield east of the class rooms consists of made or filled-in ground, with slates coming up only on the east side. It is in this filled-in ground that the fissures developed, and not in the slates, which actually, close to the Laidlaw Hall,

1. There appears to be an error in nomenclature. The P.W.D. have designated the upper terrace, next to the Laidlaw Hall, the Sportsfield, and the larger terrace below the class rooms as the Playground. The terms should be reversed, but are retained in this note so as to avoid confusion.

diverted the fissuring. The same feature probably applies to the Playground below. There are some rotten slates on the slope between the Playground and the Sportsfield, which may be almost in situ, but they are not of the same compact nature as those at the south-east corner of the Laidlaw Hall and east of the Sportsfield. If the fissuring were really continuous between the Sportsfield and the Playground, it must have descended into the rotten slates between the two terraces, but against this must be remarked that the fissuring avoided the sounder slates and was for the most part only present in the filled-in ground.

The Chairman of the Municipal Board suggested to me that the subsidence may have been towards the east side of the Hallet War School ridge, away from Naini Tal. This is not so, for the reason already stated that the fissures were diverted away from the eastern side of the hill ridge by the slates cropping out there.

It is to be regretted that no trenches were dug across the crack lines in the Hallet War School, so as to reach the slates underlying the filled-in ground. These would have indicated the depth and nature of the fissuring, and the type of rock-fill used in construction of the Philander Smith buildings. Indeed, apart from the solitary record of F.O. Oertel, in 1895, we have no positive information about existence of the Sher-ka-Danda cracks in rock as distinct from soil cap. Oertel's information was ambiguous, if it is true that the rock in which the old main fissure was observed was a limestone because solution channels are common in limestone, (page 35).

Coulson stated that the fissuring certainly descended below the soil cap into the underlying slates, and may have gone down almost 50 feet. Possibly there was more evidence available for this assertion in 1939, but this is not made sufficiently...

sufficiently manifest in his Report. The evidence is now ambiguous, and I do not consider it certain that the fissuring was either continuous from the Dormitory to the Playground or deep seated and in the slates as well. The observed subsidence was, so far as I can see, confined to the filled-in ground, and may have been partly along the contact of the fill with the true slates below. This suggests that compaction of the filled-in ground, accelerated perhaps by the earthquake vibrations in 1934, may have been responsible for some of the ground settlement and cracks in buildings. The same remarks apply to cracks in Oak Openings, Breamar, and the Towers, which are all partly constructed on rock fill material made up with slate rubble.

I do not wish to be too positive on this point, as it is likely that some of the evidence as to the nature of the fissuring has now been obliterated. What evidence there is, however, would seem to indicate:-

- (1) that the new fissures of the Philander Smith College do not follow the strike of the slates, but run oblique to them;
- (2) the new fissures were deflected by sound slates, and ground subsidence seems to have been confined to areas which have been filled in with rubble;
- (3) it is possible that the fissuring was superficial, and only to a slight extent connected with sporadic jointing in the underlying slates.

Theodolite observations of pillars and measurement of pegs flanking the ground fissures have not indicated any movement since 1938, but it must be stressed that the years 1939-1941, inclusive, were years of low rainfall, and it is possible that movement will only become measureable after the heavy monsoon of 1942 (see 1907 Committee findings).

The issue is therefore that with the evidence at present available there is a difference between the old main fissure, about which it may be remarked nothing significant has been heard since 1907, and the new fissures which have recently

-developed south-east of the St. Loe Gorge. The latter are not continuous although they do keep to a more or less definite alignment on or close to the crest of the ridge. To a large extent they appear to be located in filled-in ground, which experience shows to be liable to compaction and differential subsidence. Finally, there has been no movement of the pillars or pegs during the period 1939-1941, which happen, however, to be years of low rainfall.

3. Reason for extending the Prohibited Area in 1939.

As a result of Coulson's examination of the Hallet War School, he considered that a dangerous slip south-east of the St. Loe Gorge is a possibility, and the prohibited Area was consequently extended south-east of drain 13 right to the exit of the lake, and the Ramsay Hospital. My interpretation of the evidence near the crest of the ridge is that the danger does not appear to be as pronounced as was suggested by Coulson.

It cannot, in my opinion, be stated with certainty whether the symptoms which appeared between 1950 and 1938 are the early signs of a major collapse, a conclusion favoured by Coulson, or are merely indications of minor and relatively unimportant settlement. Time must elapse, and more pillar and peg observations must be taken (particularly during wet years) before it is possible to decide.

It is certain that the protective recommendations made by Coulson were sound. Now that those recommendations have been carried out, it is possible that the hill side south-east of the St. Loe Gorge may be regarded with somewhat less suspicion. It would be most unwise, however, to throw caution aside, assume that there is no danger, and to build at will. It is well to stress here the point emphasised long ago by Holland (1896 report: para. 117) that the forces of erosion are always working, assisted by gravity, and that there can be....

be no absolute immunity from erosion and slips. The protective measures hitherto taken are not rendered thereby a waste of time and money, in a hopeless battle against impossible odds. The geological cycle is a matter of many million years, and the protective measures are admittedly a short term policy taken out, not to eliminate the danger to life, which is out of the question, but to lessen it. This point has been stressed because there is an idea current in Nini Tal that, since nothing can stop the ultimate degradation and base levelling of the Himalayan chain, the whole question of hillside control has become an unwarranted nuisance.

4. The Jakhwal Sadan Bulge

It is now necessary to discuss the bulge overlooking Jakhwal Sadan and Castleton, mentioned by Coulson on p.31 of his report on the Safety of certain area.

The Chairman of the Municipal Board has suggested to me that Coulson was the first geologist who has made any comment on this bulge, and has implied that its inclusion in any argument is somewhat gratuitous.

The bluff mentioned by Coulson is actually steeper than the 1:1 slope (45°) shown in his section IV. Mr. Bhola Dutt and I found an almost vertical cliff, 50-100 feet in height, between about the 6900 and 7000 feet contours. This cliff consists of minute slate, calc-slate, and occasional limestone fragments set in a matrix of calcareous soil. Mr. Dutt pointed out that the bluff lies at the same level as that which has had to be underpinned below the Infectious Diseases Hospital, and suggested that the cliff face might actually be the face of an old landslip which had extended from the Infectious Diseases Hospital to near Devi Lodge.

The dolomitic breccia which forms the bluff by the Infectious Diseases Hospital was found, however, to strike northwards....

northwards up the Sher-ka-Danda Ridge to Municipal Boundary Pillar 23, and is not continuous with the cliff above Jakhiwal Sadan. It is difficult to give an explanation of this cliff. The line in the soil matrix has certainly descended as soluble bicarbonate from the overlying limestone beds near the top of the hill, and been redeposited as calc-tufa in the soil. But it is difficult to explain the steepness of this bluff, which may possibly represent the slip face of an old slip in superficial debris. The area is densely covered by trees and exposures are poor. Without more data, it is not possible to state the exact nature of the cliff.

5. Mitigating Factors Concerning Extended Prohibited Area.

Descending now to the lower slopes of the extended prohibited area, the slates vary in direction of dip from N.W. to N.N.W., the strike being either coincident with, or within 15° from, the direction of maximum ground slope. Consequently the resultant force of gravity acting along the apparent dip down the slope is small or entirely absent. Although the slates are sheared, they are less jointed for example, than the typical Lower Krol slates of China and the Depot Road.

Considered solely from the point of view of foundations to buildings, these slates may be considered as satisfactory, and better than most of the slates in the neighbourhood.

In discussing the stability of any particular site there are two factors to be borne in mind:-

- (1) The stability of the site itself, and the hillside below it;
- (2) The stability of the hillside above the site.

With regard to the Extended Prohibited Area it is seen

that there are reasonably sound slates in the lower gentle slopes of Sher-ka-Danda dipping in a direction which favours stability. Considering the lower slopes alone, without reference....

reference to what lies above them there would seem to be no objection whatsoever to construction, provided that certain conditions are satisfied.

The issue depends, therefore, on the conclusions drawn with regard to the stability of the upper part of the hill side from Jakhwal Sadan to the Hallet War School. Until more is known about the existence or absence of movements on the south-east portion of Sher-ka-Danda, and the behaviour of the fissures of the Hallet War School, it would be unwise to release this portion from the Extended Prohibited Area.

Since much depends on the taking of the theodolite observations and steel-tape measurements, it would be advisable that they are carried out, or at least thoroughly checked, by a senior officer such as the Assistant Engineer. His present duties are onerous and it is clearly impossible for him to be responsible for the observations unless an additional overseer be appointed, as was, I understand, recommended by the 1937 Committee. It is clearly essential that these observations should be unbiased, and not influenced by any well-meaning desire to consider the slopes finally cured of their canker, and hence beyond reproach.

III. POSSIBLE REMOVAL OF BAN FROM EXTENDED PROHIBITED AREA.

The suggestion I would put forward for the consideration of the Committee is as follows. Theodolite and steel tape observations should be continued. If, after two consecutive years of high rainfall (over ^{710"}~~440"~~ per annum), or two years of high rainfall within a period of three consecutive years, there is no accelerated movement of the slopes as observed by pillars, and the sporadic fissures of the Hallet War School do not widen, or show recurrence, or extend longitudinally, then the lower portion of the hill side south-east of drain

13 (Canning House) and below the 6750 ft. contour may be considered as relatively safe and buildings may be constructed thereon.

✓ The conditions which I would suggest for this area of plates below the 6750-contour are:-

- (1) No construction should be on a slope composed of slate or shale rock which is steeper than a gradient of 1:2, or $26\frac{1}{2}^{\circ}$ or $26\frac{1}{2}^{\circ}$.
- (2) Buildings should be of light design, preferably earthquake-proof, with foundations as a single unit.
- (3) Retaining walls should be of the standard section, with a face batter of 1:3, and reaching down to slate rock.
- (4) The filled-in portions of terraces should be of masonry rubble rather than soil with slate fragments
- (5) Drainage should be adequate, and the drains made pucca.

The choice of a gradient of 1:2, or $26\frac{1}{2}^{\circ}$, is not entirely arbitrary. Middlemiss considered only slopes between the debatable angles of 25° and 35° , (the latter angle being raised by Holland to 37°), remarking that slopes below 25° may be considered safe, apart from exceptional circumstances.

For convenience while examining the maps, and as a preliminary to making detailed levels of sites which come under consideration, the following data are given for the old 1899 map of Naini Tal on the scale of 10" = 1 mile (1:6336), the contours of which appear to be very accurate:- a gradient of 1:2 implies a distance on the map between the 100 feet contours of 0.379" or 9.62 mm, or with slightly more approximation, there should be 1.0 cm. or 0.40" ($25^{\circ}14'$ angle) between the 100 foot contours. This interval can be readily read off by dividers. Any 100 ft. contours closer than 1.0 cm or 0.40" imply a steeper gradient and the area should be condemned.

The.....

The contours of the modern Guide Map of Naini Tal, on the scale of 6" = 1 mile, are not accurate enough for the purpose.

It will of course be necessary to run accurate sections but the 10" = 1 mile map affords a preliminary guide as to places which should not be built upon.

These points will be discussed again in Section XIV, in which I have extended the conditions given above to the whole of Naini Tal.

XIII. REVISION OF PROHIBITED AND SAFE AREAS.

1. General Question of Safety.

It has not been possible for me to read the whole literature concerning the establishment of the Prohibited and Safe Areas, but it is perhaps advisable that the whole question should be subject to a renewed examination. The adjectives Safe and Dangerous as applied to these areas are in most cases deceptive, since they imply an absolute dichotomy for which there can in actuality be little justification. There is potential danger in all hill sides, and all who live in hilly regions have to take a certain risk. Were this not so, Switzerland would be almost uninhabited except for the molasse plain.

Seismic Regions.

Similarly, those who live in seismic regions also run a considerable and greater risk, notwithstanding which Japan, the coastal belt of California and southern Italy are densely populated regions.

In New Zealand, California, Japan and Italy there are building codes which lay down regulations concerning the erection of ordinary dwelling houses, larger offices, factories etc. The codes demand for the larger buildings the

structures should be designed to withstand shocks in which the acceleration of the seismic waves is 3.2 feet per second or one tenth g. This corresponds approximately to isoseismal 8 of the Mercalli scale. In major shocks, however, much higher intensities are reached over limited areas, the acceleration of the seismic waves sometimes exceeding 32 ft. per second. No seismic legislation can provide, however, for the severest shocks, since structures built to withstand them would be excessively costly and in alluvial areas damage would be incurred, notwithstanding a very rigid construction, on account of slumping.

The areas which actually experience the maximum effects of earthquakes are small compared to those in which damage, although widespread, is less severe. As an example may be taken the Bihar-Nepal earthquake of 1934. The areas within the higher isoseismals are indicated below:-

Area within Isoseismal : 10 (maximum intensity)	1,300 sq. miles
9	14,000
8	31,000
7	109,000

General ruin was experienced within isoseismals 9 and 10, over an area of 14,000 sq. miles. On the other hand, buildings were cracked, and minor damage was incurred, over an area of $109,000 - 14,000 = 95,000$ sq. miles. This represents the area which was damaged, but escaped severe destruction. The area of severe damage was thus only 14.7 per cent of that in which damage was not ruinous.

It is seen that, in seismic countries where there are building codes, the regulations are designed to ensure a reasonable measure of safety, but that even so along certain zones people run a risk of more severe damage and loss of life, a risk which is reduced but not eliminated, by the building codes.

Returning.....

Returning to the question of hillside stability, the protective measures adopted at Naini Tal likewise reduce the risk of damage, but they can be no guarantee of absolute safety and immunity from danger, in either the so-called Prohibited (Dangerous) or the Safe areas. Those who expect such absolute immunity forget the dangerous and vicissitudes inherent in living.

2. Old Prohibited Area North-East of Lake.

It was recommended in Section XII that the ban should be removed from the extended Prohibited Area, south-east of the St. Loe Gorge, provided theodolite and other measurements indicated no extension of the recently developed cracks or abnormal hill movement after a period of high rainfall.

Since no movement has been observed for many years along the old main fissure north-west of the St. Loe Gorge, which lies above the original Prohibited Area, it might seem logical also to remove the ban also from this area.

There is one important difference, however, between the old Prohibited Area and the extended one. In the latter the slates are moderately tough and dip N.N.W. or North-West, across the slope of the hill. In the old Prohibited Area, the slates are more cleaved and dip West or W.S.W., nearly coincident with the slope of the hill side. Structurally, therefore, the slates in the old Prohibited Area are less well disposed in relation to the ground slope, and it is in this area that the 1867 and 1880 slips took place.

In spite of this potentially unstable condition, the whole of Malli Tal, and many of the important buildings to the north lie below this hillside, and the boundary between the safe and Prohibited areas rather anomalously winds about so as to remove certain buildings from a ban under which really they should consistently be included. The difference

between the old and the extended Prohibited Areas is one of degree, and is based on the change in the dips and strikes of the slates, as well as on a slight change in the nature of the slates. Geologically, therefore, there is a slightly greater risk in constructing buildings in the old Prohibited Area, but it is a risk which many people have for a long time been prepared to take. The curious zig-zag disposition of the boundary between the Safe and unsafe areas north and east of the Malli Tal bazar. appears to me to have no basis of geological fact to support it, and suggests a desire to introduce a bogus sense of security to ^{Continue buildings which cannot} a stroke of the pen. ^{advice}

Granted that there is structurally, from the available evidence, a slightly greater risk of landslips in the old Prohibited area, I see no reason nevertheless why further construction should not be permitted there below the 6750 contour and on slopes with a gradient not exceeding 1:2, or $26\frac{1}{2}^{\circ}$.

3. Prohibited Area South-West of Lake.

The Prohibited area south-west of the Lake may now be considered. This area is mostly in slates, although at the south end are Upper Krol Dolomites, together with sandstones, quartzites and shales which are probably Upper Tal.

Taking the northern part of the area first. The slates dip uniformly towards the N.N.E. at angles varying from 30° to 40° , which is coincident with the general direction of maximum hill slope. The angle of dip, on the other hand, is only coincident with, or less than, the ground slope in a few places, such as Glenlee and Fir view. Elsewhere the angle of dip is steeper than the ground slope, a condition favouring stability.

These slopes are figured by Holland in section 8, and sections 13 to 16 inclusive, in his 1896 report.

The...

The demarcating line between the Prohibited Area and the Safe Area runs from St. Andrews to the Priory. It includes such definitely geologically unstable sites as Fine View (Slope of 30°) and below Glenlee (Slope of 40°), but it separates geological similar and stable sites such as the following:-

Prohibited Area

Safe Area

Aarglesford (strawberry Cottage of 1899 map)	$15^{\circ}-20^{\circ}$	Strawberry Lodge	15°
Rose Bank	14°	Thanet Villa	14°
Leonard Villa	20°	St. Andrews	12°

All such boundaries are of necessity somewhat arbitrary, but the inconsistencies or portions of the boundaries in Naini Tal are certainly striking. The criterion which should be adopted is the gradient of the ground slope, and Holland's 1895 Geological Map of Naini Tal affords the best clue as to what sites are to be regarded with suspicion, and condemned future for/~~xxxxxx~~ building. Holland has shown slates lying outside a slope of 37° in dark colour. These places should definitely be banned, but I would favour including all ground slopes in slate areas steeper than $26\frac{1}{2}^{\circ}$ or 1:2 in the ban, which merely means a slight extension of the dark slate colour on Holland's map, and can be determined by dividers.

The southern part of the Prohibited Area is coloured by Middlemiss as Massive Limestone (Upper Krol Dolomite) but is to a large extent made up of probable Upper Tal rocks. Holland retains Middlemiss's classification, but indicates on the map the places where non-dolomitic rocks occur.

It.....

It is in this region that the 1939 landslip, predicted by Holland in 1893, took place. Holland's Section No. 16 gives his interpretation of the structure, which the recent landslip scar has shown to be only partially correct, for the structure is synclinal, and the slip appears to have taken place along the shattered axial plane.

The boundary between the Prohibited and Safe areas in this region is sound.

It may be noticed, however, that there are sites in the so-called Safe Area to the south which have been subject to soil cap creep and minor slips. Purebeck Lodge is an example (See Section VII p. 19). This site, although not showing any basic structural instability, is on a slope of 34° , and has suffered from fissuring in the terrace material and slips in the Soil-cap below. It is with more justification an unsafe area than are either Clifton or Arglesford (Strawberry Cottage). I may also mention the site 280 feet North-West of Dereham House which I have had to condemn although it occurs within the Safe area.

4. Revision of Categories advised.

Since the generalised division into Prohibited and Safe Areas inevitably leads to local irregularities in classification, it is suggested that such an assessment should be abolished, and that an attempt should be made instead to adopt a code based on geological principles. It is not claimed that the conditions formulated below are entirely satisfactory, ~~but they probably render a maximum fairer result~~ because all categories are to some extent arbitrary but they probably render a possible fairer classification than the one at present in force.

~~In cases of doubt, reference can be made to the Geological Survey of India, which has a party working annually~~

In cases of doubt, reference can be made to the Geological Survey of India, which has a party working annually in the United Provinces. But it should be insisted that, if the Committee agrees to the proposals put forward here, they should be rigidly adhered to, and no exceptions should be allowed. Once a request is granted, on the plea of exceptional circumstances, to construct buildings in places not permissible under the code suggested below, the Executive Engineer will be flooded with petitions, which will be hard to refuse with equity.

XIV. SUMMARISED STATEMENT OF CONDITIONS PERMITTING CONSTRUCTION.

The following cases may be considered for the slopes around Naini Tal. They do not apply to the softer clays of the Upper Tertiary rocks lying between Jeolokot and Kathgodam. These cases are based to a large extent on the earlier conclusions of Middlemiss and Holland, with certain alterations.

In general the hillsides are concavo-convex, and construction is considered for the lower concave slopes, when existent, and any upper gentler slopes towards the crest of the ridges which lie above the convex slopes and steeper middle regions.

Many dips are shown on the 1895 map of Holland. By "Apparent Dip" is meant here the value of the dip in the direction of maximum ground slope in those cases where the maximum or ^{true} dip (perpendicular to the strike) does not coincide with the maximum ground slope. The apparent dip is calculated from the relationship

$$\tan A = \tan D \cos X \quad \text{where } A \text{ is the apparent dip}$$

D. the true dip
X the angle between the direction of true dip and the maximum ground slope.

A gradient of 1:2 has been adopted as the criterion.

Such a gradient should be the average over a slope the vertical height difference of which is not less than 100 feet. Small patches with a gradient less than 1:2 in an otherwise steep hill side cannot be considered favourably. Furthermore, the slope with a desirable gradient of 1:2, or less, should include a sufficient portion of the hill side behind the site so that excessive ^{excavation} and high retaining walls are avoided.

✓ A. Lower Portions of Hill Sides, near Lake.

1. Slope less than $26\frac{1}{2}^{\circ}$ (gradient 1:2).

Apart from outcrops of the Krol Red Shales and highly weathered slates, slopes of less than $26\frac{1}{2}^{\circ}$ may be considered as reasonably safe whatever the structural disposition of the rocks. The deciding factor is the stability of the hill side above.

- ✓ (a) The question of building below the 6750-contour in the extended Prohibited Area depends on the results of the theodolite and steel-tape measurements carried out during two consecutive years of high rainfall or two years of high rainfall in three consecutive years.
- ✓ (b) Slopes of less than $26\frac{1}{2}^{\circ}$ may be built in the Old Prohibited Area north-east of the Lake, since no theodolite or other observations have indicated any abnormal movements in the hill side above for many years.
- (c) The Prohibited Area South-west of the Lake. Building is not to be permitted below the 6650 contour (10" map) as the ground slope is almost everywhere greater than $26\frac{1}{2}^{\circ}$.
- (d) Present Safe Areas: Building should be avoided on those slopes of the areas at present regarded as

safe.....

safe in which the declivity is more than $26\frac{1}{2}^{\circ}$ for slates and shales, and 30° for sound dolomite and sandstone.

2. Slope between $26\frac{1}{2}^{\circ}$ and 30° (gradient 1:2 to 1:1.73)

(a) No building on slates.

(b) Building permissible on dolomite, sandstone or quartzite, if the apparent dip of the dominant divisional plane is favourably inclined to the ground slope.

3. Slope greater than 30° (gradient 1:1.73)

No building permissible.

B. Upper Portions of Hill sides.

The deciding factor is the structural aspect of the convex and steeper underlying portions of the hill, below the gentler upper slopes. The factors enumerated on page 28 must all be considered, but the issue may be simplified by considering primarily the direction of the dominant divisional plane (generally bedding, but sometimes cleavage and jointing) in relation to the ground slope of the steeper hillside below.

1. The apparent dip of the dominant divisional plane is into the hill at angles greater than 10° from the horizontal. Construction permissible on slopes of less than $26\frac{1}{2}^{\circ}$ up to within 30 feet of the steepening of the gradient below the site.
2. The apparent dip of the dominant divisional plane is inclined down the slope, but at an angle more than 15° in excess of the maximum angle of ground slope. Construction permissible as in B 1.
3. The apparent dip of the dominant divisional plane is inclined down the slope at an angle roughly coincident with, or less than, the maximum slope of the hillside below the site. Construction should only

be permitted well away from the top of the steeper convex slope so as to avoid any slips that might occur in the wedge between the divisional plane and the steep portions of the hillside.

4. In places where exposures are poor, and the structure is not clear, building should not be permitted without excavation to determine the nature of the rocks.

✓ C. General Conditions.

1. The pucca drains should be maintained, as heretofore.
2. Construction of buildings should be according to the suggestions laid down on page 46, viz.
 - (a) Light buildings, preferably earthquake proof, with foundations as a single unit.
 - (b) Retaining walls to be of standard section and based on rock.
 - (c) The filled-in portions of terraces should be constructed of material which will not be subject to large volumetric changes due to compaction and variations in the water content. Sufficient time should be left for compaction to take place before construction is permitted.
 - (d) Adequate drainage for any area excavated.
3. The above conditions should be subject to periodical review in the light of experience which will be gained in the future.

Calcutta, 15th August, 1942.

Minutes of the meeting of the Sub-Committee of the Safety of the
Hillside Committee, held on October 2, 1942.

PRESENT: Mr. M.B. Hatfield, I.S.E. Superintending Engineer P.W.D.
Mr. J.B. Auden, Geologist.
Mr. Z.A. Vahidy, (Senior) Executive Engineer
and co-opted R.S. Pt. Bhola Dutt Pant, Assistant Engineer.

(1) The minutes of the Safety of the Hillside Committee meeting held on Sept. 28 1942 were discussed. The recorded minutes referred to pages in Mr. Auden's typed report. As this report is likely to be printed in the future the pages of the printed copy will not agree with the pages of the typed copy. In addition to the page numbers of Mr. Auden's typed report reference to chapter numbers and subsections should be given.

(2) The following reference to chapters and sub-sections of Mr. Auden's report used to be added:--

After page 3 Rec. 7 add 'Chapter VI'
After page 3 Rec. 24 'Chapter I Sec. 3"
After page 8 'Chapter II, Sec. 3"
After pages 9, 10 & 11 No. 5 add "Chapter III, para 5"
After pages 9, 10 & 11 No. 8 add "Chapter III, para 8"
After page 17 add "Chapter VI"
After page 18 add "Chapter VII, Sec 1"
After page 19 add "Chapter VII, Sec 2"
After pages 19-20 add "Chapter VII, Sec. 3"
After page 21 1.4 add "Chapter VII, Sec. 4"
After page 45 add "Chapter XI, Sec. 5"
After page 46 add "Chapter XII"

(3) Chapter III, para 5 of Mr. Auden's report.

Mrs. Grant's site:-- There was an error in identification of this site. Mr. Auden visited the true site, which is in the angle between Melville and Almora roads, and considers it to be sound, Building may be permitted on this site, subject to the conditions suggested on page 46, Chapter XII of his report.

(4) Chapter VI of Mr. Auden's report with reference to the intensification of drainage on Gangipur Hill.

Mr. Auden was under the impression on a second visit to the pipe line below the Gangipur spur between anchor blocks 93 and 107 that considerable surface creep in the rotten weathered slates is taking place. He considers that in this area should be dewatered further by the addition of herring boned feeders to the existing drains. This should be done.

(5) Chapter VII. Sec. 1. of Mr. Auden's report.

Fine View:-- There is an undrained gully running down a few yards to the south-east of the Fendennis pucca drain, along which erosion appears to be negligible although percolation of rain water is likely to be considerable. It was agreed that unless there are further signs of pressure on the reconstructed retaining walls, this gully may be left unlined, and no further draining operations are required.

(6) Chapter VIII Sec. 2 of Mr. Auden's report.

Killarney Area:-- The Killarney slip of 1939 was re-visited by the Superintending Engineer, III Circle, and Mr. Auden together with the Executive Engineer, Naini Tal, and the Assistant Engineer, Naini Tal. It was agreed that the East Laggan Road should be constructed across the face of the slip by cutting into the S.E.W. face of the hillside which forms the northern boundary of Killarney and the adjacent tennis court. The new East Laggan Road will take off from the diversion on the west side of the slip bearing of approximately 135° and continue towards the crack line north of Killarney and the north side of the tennis court. The stability of the hillside above the road such as it is will not be seriously engaged by this cutting, since only 30 to 40 feet between the road and the Killarney terrace will be affected. The area is basically unstable, but the reconstruction of the road should not be condemned thereby. Should further slips occur, the road can be still further cut back towards the S.S.W. by encroaching upon Killarney and the tennis court.

St. Helens:-- Considerable surface creep of the Lower Krol slates and soilcap is taking place above St. Helens, down a slope of from 40° to 43° and in places minor slips have occurred. The back wall of the ground floor of this house is the retaining wall against the hillside. This wall is considerably bulged. More retaining walls are required at the back of the house from the level of the upper corey. The practice of making one wall of the house the retaining wall of the hillside should be condemned.

(2)

Chapter XI, Sec. 2 of Mr. Auden's report.
Waldlow Hall, Walleder War School (Phyllander Smith College) creek— Mr. Auden
opinion that no useful purpose would be served at the present time if trenches
are dug across the crack line in this area, but should any movement of hill-side
occur along these crack lines then trenches should be dug to reach the rock
to ascertain if the cracks originate in the sandstone.

Chapter XII, Condition (2) and Chapter XIV General Condition C, para 2(a).
A single unit foundation is defined as a foundation consisting of reinforced
concrete or reinforced cement bricks (1:2:4) the whole foundation being
monolithic, or steel frame work.

These minutes are subject to the approval of the other member of the main
Committee.

Minutes of meeting of Safety of Hill-side Committee, Naini Tal
September 28, 1942.

- PRESENT: 1. Mr. T.J.C. Acton I.C.S., Deputy Commissioner
In Charge Kumaon Division.
2. Mr. M.B. Hatfield I.S.E. Superintending Engineer, III Circle
Provincial Works.
3. R.S. Th. Jashaud Singh Bisht, B.A., LL.B.,
Chairman, Municipal Board, N.T.
4. F.D. Tunncliffe, Esq., M.C. P.H.D., Superintending Engineer
Public Health Department
5. Mr. Z.A. Vaidy (Senior), Executive Engineer, Kumaon Provincial
Division.

(Note:—These minutes should be read in conjunction with the previous
minutes of July 3rd and 3th 1942.

- Auden's 1942 report. Rec. 7. No action is necessary.
- Page 3. Rec. 24. No action need be taken to remove Tulsi Das's Cottage. Cultivation has been stopped. Sloping of the cultivated ground is necessary and should be done by the P.W.D. in consultation with the Station Staff Officer. S.S.O. is willing to co-operate.
- Page 8. Blasting of loose material and detached boulders at Pateria should be allowed but not blasting of stone embedded in the hill-side.
- Page 9, 10 & 11. No. 5 There is some doubt whether Mr. Auden correctly identified site no. 5. Executive Engineer should ask him about this and verify, and then decide.
- No. 8 The drains recommended should be constructed by the P.W.D. Otherwise the recommendations on sites 1 to 9 are accepted by the Committee.
- Page 17. Superintending Engineer, B. & R. will ask Mr. Auden what intensification of drainage he recommends. New toll-tales should be put into the anchor blocks in addition to the old ones as the latter were put in before the drains were made.
- Page 18. Fine View:— Superintending Engineer, B. & R. will ask Mr. Auden what improvement to drainage he suggests. The retaining walls should be re-built by the owners of the properties concerned.
- Page 19. Killarney area. Superintending Engineer and Executive Engineer, B. & R. will discuss further with Mr. Auden and decide what can be done about restoring the Middle Ayarpatta Mall and East Lagoon roads across this area.
The nala below Edwinatowe Cottage is being lined.
- Page 19-20. Purbeck Lodge. The recommended retaining wall has been built by the Municipal Board. The cost of it should be recovered from the owner of Purbeck Lodge.
- Page 21. Line 4. The drain referred to should be diverted by the Cantonment authority in consultation with the Executive Engineer.
- Page 45. Last paragraph. The Committee agree that an additional overseer is necessary for theodolite and steel-tape measurements, and should be appointed, after suitable training, for a definite period of three years during which he should not, if possible, be changed.
- Page 46. The committee agree with these recommendations.
- Page 53. Chapter XIV. Recommendations should be accepted, subject to the condition that no buildings should be permitted on a slope of which the average is steeper than 1:2 irrespective of the composition of the hill-side, and retaining and breast walls must invariably be to the P.W.D. standard sections for hill areas.
The recommendations should be embodied in the form of byelaws to be compiled by the Board in consultation with the Executive Engineer and submitted to Government for sanction.

T.J.C. Acton
Deputy Commissioner,
In Charge Kumaon Division.

Proceedings of meeting of Safety of Hill-sides Committee Naini Tal
July 8, 1942.

PRESENT: 1. Mr. T.J.C. Acton I.C.S., D.C. I/c Kumaon Division
2. R.B. Th. J.S. Bisht, B.A.L.L.B., Chairman, Municipal Board Naini Tal
3. Mr. M.B. Hatfield, I.S.E., Executive Engineer, Kumaon Provincial Dn.
4. Mr. J.B. Auden, Geological Survey of India.
5. Mr. F.D. Tunnicliffe, M.C.P.E.D., Superintending Engineer, P.H.D.
6. Mr. Niranjan Lal, Electrical Engineer, Municipal Board, Naini Tal.

1939 Report of Dr. Coulson on the Power pipe-line.

Recommendations considered;

Observations are made every week in the rains and have been recorded since August 1938. Movement has been very slight.

The slipping area has been sloped and drained.

Buttress not constructed. No action necessary. The anchor block no. 83 is under observation with bell-tees.

4,5,6. Done.

7. Mr. Auden will examine this and report whether the work done is sufficient.

8,9,10,11,12,13,14,15,16 Done.

18. Mr. Hatfield thinks that this drain should be lined. The work has so far been postponed for the execution of the Hais Hotel pumping scheme, but the water from that spring is securing the drain and the Committee thinks that the drain should be lined as soon as possible.

17,18. Done.

19. Grazing has been prohibited and cases are being regularly prosecuted.

20. Done. Grouted, and underpinning repaired.

21. The most urgent bed-bars have been or are being built, and have proved successful.
22. There is an estimate of Rs. 70,000/- for those towards which Government has given an annual grant of Rs. 7,000/- for the four last years. The Committee consider that this work is urgent and that the balance of the estimated cost, which is now Rs. 42,000/- should be provided in the next two years.

23. Done, except for bed-bar no. 15 which has not been constructed because there is an outcrop of rock at that point. Mr. Auden will examine this and report

24. Action taken by the Cantonment authorities has so far been negligible. The Committee recommends that the work should be done at once by the P.W.D. as the Cantonment authority has no suitable agency, and that Government should ask the Defence Department to meet the cost. The Executive Engineer should prepare an estimate and send it to Government, with a proposal for transfer of control of this plot from the Cantonment to the P.W.D.

It should also be recommended to Government that no buildings or drains should be allowed to be constructed within the Cantonment area without the consent of the Executive Engineer, because any new buildings, and especially insufficiently drained sites are a danger to the stability of these hill sides and therefore to the Pipe-line.

CHAIRMAN, MUNICIPAL BOARD'S NOTE OF 1.7.42.

I. (a) Mr. Auden says that it is impossible to give any guarantee. He agrees with Dr. Coulson's recommendations and warnings. The Committee recommend that the stand-by station at Kathgodam be constructed as soon as possible and that, in order to ensure some return on capital, the Naini Tal Board be given the electric licence for Haldwani, Kathgodam, Bhowali, Ranikhet and Almora. Supply to the first three would be taken up as soon as the cost and supply of materials permit, and the other two later. The Committee also recommend a loan of 2 lakhs for electrification of Haldwani at the reduced rate of interest of 2½% which Government have agreed to in the case of other loans for Naini Tal.

(b)&(c) A diesel engine of 400 h.p. would be necessary and no engines of this kind are at present available. The risk is chiefly of a large slip damaging the power house itself, as damage to the pipe-line could be repaired within a few days, sufficient spare pipes being available. This risk is, in the opinion of the Committee, unavoidable.

II. Mr. Auden will examine the proposed sites and report, so that an expert geologist's opinion may be on record. The scheme is estimated to cost about

becomes necessary to save for other electric uses the electrical energy now used for pumping.

Superintending Engineer, Public Health Department's Proposal to run a 12" sewer down the Ballia ravine and construct a 50,000 gallon settling tank and a filtering filter at some suitable place alongside the ravine and as short a distance from the dhobi-ghat as possible.

Mr. Auden will report on this proposal in respect of its effect on the safety of the hill-side concerned.

REPRESENTATION BY THE CHAIRMAN MUNICIPAL BOARD ABOUT FINANCE.

This is outside the scope of this Committee but in the recommendations of the ecologist and of this Committee the Municipal Board must have to undertake expenditure for a stand-by plant and has had to incur very large capital expenditure in the past. It is therefore brought to the notice of Government that the Board's financial position is likely to become impossible in the near future unless substantial help is given by Government.

The Committee will hold another meeting in September to consider points raised in Mr. Auden's report of which He will send a copy to the Commissioner.

T.J.C. Auden

Deputy Commissioner in Charge
8.7.42. Kumaon Division.

Proceedings of meeting of Safety of Hill-sides Committee
Maini Tal. July 3, 1942.

- PRESENT: 1. Mr. T.J.C. Aston I.C.S. D.C. I/c Census Division.
2. Mr. W.F. Walker, M.C., I.S.E., Superintending Engineer, II Circle
3. R.B. Ti. Jashwan Singh B.A.L.L.B. Chakrasan Municipal Board *Prof. Jashwan Singh*
4. Mr. M.S. Hatfield I.C.E. Executive Engineer, Kumaon Prov. Dn.
5. Mr. J.B. Auden, Geological Survey of India
6. Mr. F.D. Goodcliffe, M.C. P.H.D., Superintending Engineer, P.H.D.

1959 Report.

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Recommendations considered:

- (4). Chief Engineer inspected on 23.5.40 and did not agree. Erenton Hall should
- (5). be kept under observation for cracks.
6. Building is not dangerous but is under observation.
7. Not dismantled. Tell-tales on the walls, but Executive Engineer should record an inspection of these once a year.
12. Tell-tales should be inspected annually.
13. Chief Engineer considered it sufficient to remove upper storey and a stringer course provided. The Committee agrees that this is the best treatment in the circumstances as demolition and substitution of a really earthquake-proof single storey building is not necessary at present.
16. A length of 20 ft. of pucca drain remains to be provided.
24. Boulders have been removed instead of under pinning.
28. Oak Ridge house, which as above, has been demolished and in view of this a new drainage it is not now necessary to demolish the tenement house referred to.
31. The proprietor Pt. Ram Patt Joshi should be given a fixed time within which the work must be done; failing compliance the work should be done by the Municipal Board and the cost recovered.
32. As above - the proprietor is Kunwar Anand Singh. The wall has been done, but the tennis court has still to be drained.
45. As for no. 31 & 32. Tara Cottage belongs to L. Brij Behari Mahan Behari. Brackenbury Hall and Tara Hall belong to Ch. Mohan Lal Varma, advocate, Almora.
47. As above. Rai Bahadur L. Uday Nath Sah is the proprietor.
48. Sites on which buildings have been refused, or on which buildings have been applied for, should be reported on by the geologist during his present visit and Executive Engineer will act accordingly.

"Light earthquake proof lines" is defined as

- (1) re-inforced concrete or (2) steel framework or (3) re-inforced cement bricks.
57. The geologist, Mr. Auden, will report on these points to Government.
58. Permits to use motor vehicles above Talai Tal should only be given in exceptional circumstances such as serious sickness.
Mr. Auden will report on the hill side above and below mile one of the Maini Tal-Rangarh road between Talai Tal and Kala Khan depot, as a crack has appeared above the road.
60. Mr. Auden will report upon the Killarney, Edwinstown and Wellesley School area
Other recommendations have been carried out.

CHAIRMAN, MUNICIPAL BOARD'S NOTE of 1. 7. 1942.
Para IV.

- (a) Executive Engineer will prepare estimates annually for the necessary work for that year and the following year so that the Municipal Board may know what funds to provide over and above the ordinary maintenance allotment.
- (b) The Committee recommends that Government should give the Municipal Board powers to enforce drainage of private compounds on the lines of Ch. XXIII of the Bengal Municipal Act (Hill Municipalities).
- (c) Mr. Auden will report whether tunnel drainage is likely to be worth the expense in any particular places.

PARA V. The Committee think that it is impossible to fore-cast what the effect of H.E. bombs would be. The chance of Maini Tal being bombed is remote, and if bombing should occur and cause a slip in any place all that can be done is to make arrangements for evacuation of dangerous areas immediately upon the occurrence of the attack.

(2)

VII. The Committee consider that their proposals on Dr. Coulson's recommendation no. 55 are sufficient. The decision on building applications in the prohibited area must remain with the Executive Engineer subject to an appeal to the Superintending Engineer as at present.

Next meeting fixed for 8.7.42 at 10.30 A.M.

T.J.C. Acton
Deputy Commissioner,
In Charge Kumaon Division.

Chairman Municipal Board's note for the consideration of the
Hill Side Committee.

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I. In 1939 Dr. Caulson in his "Geological report on the alignment of Power Pipe-line" Chapter X wrote "Indeed the geological conditions along the present alignment are actually more sound than along the alternative alignments." He recommended some 22 remedial measures for the safety of the present alignment and said "Provided that these remedial measures are adopted completely, there is reason to hope that no major dislocation of the pipe line will occur within the next ten years or more." But he recommended "I consider it absolutely essential that arrangements should be made immediately for the provision of a standby station at some such place as Kathgodam, in order that there may be no interruption to the essential services of Muni Tal" and "minor dislocations will certainly be experienced and it is for preventing these that the provision of standby station has been recommended." It appears that the present site of the Power House was disapproved by the District Engineer but was built on the initiative of the Public Health Department.

(a) In pursuance of these recommendations all the remedial measures have been carried out. The Board has three inter-lined schemes for a standby station at Kathgodam, re-conditioning of the H.T. lines and other consequential adjustments, costing in all about 13 lakhs. In view of the high prices due to war this will actually cost not less than 16 lakhs. Moreover there is difficulty in ^{obtaining} ~~obtaining~~ material during the war. It is therefore for the experts, and for the geologist in particular, to say whether the present pipe line can safely carry on for the next five or six years i.e. whether the Durgapur hill will not slip for this period. If that be so, the Board can wait till the war is over, and the prices do down.

(b) If the decision is that there is danger to the hill and the pipe line, and, if due to war, material and machinery are not available, is it possible to install a small diesel engine at Muni Tal sufficient to pump water, it being assumed that people will have to use kerosene lamps for light?

(c) In case that is not feasible how is it proposed to safeguard the water supply of the town in case of a dislocation of the pipeline or the Durgapur hill or the Kalakhan hill?

II. The Board has recently received a Water re-zoning scheme from its Consulting Engineers estimated to cost nearly 9 lakhs though the forecast was of about 4 lakhs. In this scheme it is proposed to construct the following huge tanks:

1. Ayarpatta	...	12 million gallons	...	weight 54,000 tons.
2. China hill	...	1	,,	4,500 tons.
3. Old Govt. House	4	,,	,,	18,000 tons.

It is for this Committee to decide whether these hills can safely stand this load at the top, specially at the Old Govt. House site (where the Govt. House had to be dismantled).

III. On behalf of the Board it is also requested that whatever schemes are advised to safeguard the essential services of Maini Tal, such schemes must be within the financial capacity of the Board. The experts no doubt place the responsibility on the board by advising a certain course of action. To that extent they free themselves from responsibility for what may happen. But the Board has to face an equally grave responsibility in the matter of finances. From a study of the finances it is clear that for at least six years there seems no way of meeting the deficit that will be caused by the loans on account of the schemes referred to in I (a) above. Then in about ten years the present machinery will be worn out and will require to be replaced.

The Board had to carry out the present Hydro-electric scheme in 1921 when prices were very high after the last war and the exchange stood at 2 sh. 6 d. to the rupee. On top of that heavy initial capital expenditure, if it is now called upon during this second period of high prices to undertake this large expenditure, this Committee should recommend to the Government some measure of financial relief. Other wise there is no way out of insolvency.

I am emphasising this point so that experts may bear it in mind in making their recommendations.

IV. Drainage :

(a) Road side drainage: It will appear that most of the roads have sunk below the level of roads and the side-drains fail to carry the road water which flows down hill. In the dangerous areas some plan should be recommended that will catch all this water and take it to the side drains.

(b) Private compounds: It is no use adopting elaborate measures of drainage if large private compounds remain undrained or their private roads are not properly attended to. At present the Board has no such powers to enforce ...

enforce this except the limited one of Section 192. I would suggest that we recommend to Government the adoption of the relevant section of the Bengal Municipal Act 1933 Chapter XVIII (Hill Municipalities).

(c) Sub-terranean drainage:

Dr. Coulson, differing from the report of the Technical Committee of 1937, remarks that 70 per cent of the rain water is carried off and 30 per cent sinks in the hill sides. Even so, in a year of heavy rainfall of say 150 inches nearly 80 inches sinks down, which is over four feet.

It is for the experts to say whether it is possible for them to devise any method of sub-terranean drainage. There are at least two or three small tunnels driven into the hill sides and draining the sub-terranean water of the hills. In case of continuous heavy rainfall it is the only measure that will reduce internal pressure from water.

V. In view of war conditions and the danger of air raids I also request for a decision by experts on this point. If high calibre explosive bombs are dropped on the Kailashan hill or Sargapur hill or Gharta hill what effect will it have on the safety of these hills and the consequent danger to the rope line and the tower. It is a. /P

If similar bombs are dropped along the Sher-ka-danda hill specially on Tige hill & Revenged durga or near about Kiliarney what effect will it have on the safety of these hills.

If the danger is grave it would be advisable to warn people to be prepared to evacuate the town at short notice and to make preliminary arrangements for such evacuations.

VI. Dr. Coulson in his "Report on the Safety of Certain Areas" 1939 has devoted a whole chapter -- Chapter VIII, pages 33 & 34, on the use of motor cars in Maini Tal. The Government has said nothing on this point. It is for the experts to decide whether the report is to be accepted or rejected. The Municipal Board should know exactly what its responsibility is in this matter.

VII. One important point which I press before the Committee is the controversial question of jurisdiction in building applications etc. over 'dangerous' areas. This is a subject on which the Municipal Board has always disagreed with the experts. As far back as 1929 when this was an official board, this board unanimously passed a resolution -- resolution No. 50 of 17. 10. 29 passed by Mr. H.C. Basher -- requesting the Government to lay down a definite policy regarding the treatment of applications for buildings on so called 'dangerous' or on the present discrimination between ...

between various applicants is misunderstood and causes dissatisfaction among house owners."

In 1930 the Government ^a passed rules debarring the Board from entertaining building applications in "dangerous" areas and conceding, on the representation of this board, an appeal to the Superintending Engineer from an order of the Executive Engineer.

The Technical Committee in 1937 in its report at p. 5 recommended that the Executive Engineer be vested with sole power in the whole town outside bazaar areas and if this was not approved to re-impose the 4 acre rule. This Board by its resolution No. 3 of 4. 12. 37 strongly opposed this proposal of the Technical Committee and remarked that "the present prohibited area over which the Board has no control is sufficiently large." The Government thereupon did not accept the proposals of the Technical Committee.

Then came the report of Dr. Caulson in 1939 on the safety of hill sides and acting on this report the dangerous or prohibited area was extended in 1941 so as to include the whole of municipal area in the Sher-ka-Danda hill. In other words, by an indirect method in 1941 the same result followed namely, divesting the Board of its jurisdiction over nearly 50 p.c. of Maini Tal which was not approved by Government in 1937.

It is not that the Board does not realise the gravity of the situation or the necessity of controlling building operations in dangerous areas. The Engineers accuse the Board of allowing building work in dangerous areas and the Board accuses the Engineer of discrimination as is evident from the resolution of 1929. This leads us no where. We must find some via media that will safeguard the interests of house owners as well as of the hill side. Merely vesting the power in the Executive Engineer does not safeguard the hill side. Dr. Caulson in his recommendation No. 55 advised prohibition of further building in dangerous areas but the recommendation is vague. No principles have been formulated. Everything is left to the discretion of the Engineer. I suggest that the provisions of the Bengal Municipal Act Chapter XXIII heading "Safety of the Hill sides" be adopted. That is a fair solution of a highly controversial subject. The Executive Engineer's discretion at present is like that of the Chancery Courts in England in old days when equity varied with the Lord Chancellor's foot.

between various applicants is misunderstood and causes dissatisfaction among house owners."

In 1930 the Government ^a passed rules debarring the Board from entertaining building applications in "dangerous" areas and conceding, on the representation of this board, an appeal to the Superintending Engineer from an order of the Executive Engineer.

The Technical Committee in 1937 in its report at p. 5 recommended that the Executive Engineer be vested with sole power in the whole town outside bazaar areas and if this was not approved to re-impose the 4 acre rule. This Board by its resolution No. 3 of 4. 12. 37 strongly opposed this proposal of the Technical Committee and remarked that "the present prohibited area over which the Board has no control is sufficiently large." The Government thereupon did not accept the proposals of the Technical Committee.

Then came the report of Dr. Caulson in 1939 on the safety of hill side and acting on this report the dangerous or prohibited area was extended in 1941 so as to include the whole of municipal area in the Sher-ka-Danda hill. In other words, by an indirect method in 1941 the same result followed namely, divesting the Board of its jurisdiction over nearly 50 p.c. of Nainital which was not approved by Government in 1937.

It is not that the Board does not realise the gravity of the situation or the necessity of controlling building operations in dangerous areas. The Engineers accuse the Board of allowing building work in dangerous areas and the Board accuses the Engineer of discrimination as is evident from the resolution of 1929. This leads us no where. We must find some via media that will safeguard the interests of house owners as well as of the hill side. Merely vesting the power in the Executive Engineer does not safeguard the hill side. Dr. Caulson in his recommendation No. 55 advised prohibition of further building in dangerous areas but the recommendation is vague. No principles have been formulated. Everything is left to the discretion of the Engineer. I suggest that the provisions of the Bengal Municipal Act Chapter XXIII heading "Safety of the Hill sides" be adopted. That is a fair solution of a highly controversial subject. The Executive Engineer's discretion at present is like that of the Chancery Courts in England in old days when equity varied with the Lord Chancellor's foot.


The geologist member could state the main principles on which building operations should be permitted and these should be uniformly observed. I would further suggest that light earth-quake proof structures of single brick style, which do not add any appreciable weight to the hill side, ought not to be prohibited. Naini Tal has ceased to be the Government's civil and military seat and the demand for small cottages is great. That alone will popularise the town and enable it to pay its way through. Oldham has remarked regarding the movement of the hill side (in Shar-ka-Danda) "owing to the enormous mass which is moving, and the obscurity of the cause to which the movement is due, I can see no prospect of dealing with it successfully." ~~So there is no cause to make a mystery~~ He further remarked that even if this hill had not been interfered with "there would ultimately have been a large landslide." So there is no cause to make a mystery out of it. An earthquake shock in the midst of rain as in 1880, will bring down this debris in any case. The engineers can no more stop it than laymen. Let it therefore be not made a pretext for divesting the Board of its legitimate jurisdiction.

J. S. Bisht.

Raj Bahadur B.A., LL.B.
CHAIRMAN,
Municipal Board.

1. 7. 1942.

ATTESTED:



SECRETARY,
Municipal Board,
Naini Tal.

To

T.J.C. Acton Esqr., I.C.S.
Deputy Commissioner in charge Kumaon Division,
Naini Tal.

F. D. Tunnicliffe Esqr., Superintending Engineer, P.H.D.
Metropole Hotel, Naini Tal.

W.F. Walker Esqr., I.S.E., Superintending Engineer, II Circle
Abbotsford Cottage, Naini Tal.

 J. B. Anden, Geologist, Geological Survey of India,
Eversely, Naini Tal.

M. B. Hatfield Esqr., I.S.E., EX. Engineer, Eversely, Naini Tal.

GOVERNMENT OF THE UNITED PROVINCES
PUBLIC WORKS DEPARTMENT

No. 1500 C/189C-1939, dated Lucknow, May , 1942.

From

Wajahat Hussain, Esq. I.C.S.
Secretary to Government.

To

The Chief Engineer,
U.P., P.W.D. Buildings & Roads Branch.

SAFETY OF HILL SLOPES AROUND NAINI TAL.

Sir,

With reference to your letter No. 1643CB/119CB-1941, dated March 9, 1942, I am directed to say that the Governor is pleased to appoint the following officers as members of the Committee referred to in Recommendation No. 57 of Dr. Coulson's report for the year 1939 on the safety of certain areas in Naini Tal :-

1. Deputy Commissioner in charge of the Kumaon Division, Naini Tal.
2. Chairman, Municipal Board, Naini Tal.
3. Superintending Engineer, Public Health Department, Lucknow.
4. Superintending Engineer, II Circle, Provincial Works, Lucknow.
5. Mr. J.B. Auden Geologist, Geological Survey of India, C/o Superintending Engineer, High Dams, 89 Ferozepur Road, Ichhra, Lahore, Punjab
6. Executive Engineer, Kumaon Provincial Division.

The Committee will meet during the period July 1 to 15th, 1942 and report on the general conditions of stability of hillsides at Naini Tal.

The Executive Engineer, Kumaon Provincial Division will be Secretary of the Committee and all correspondence should be addressed to him.

I have the honour to be,
Sir,
Your most obedient servant,

Sd. H. Dannett
Assistant Secretary,
for Secretary.

No. 1500(1)C/189C-1939, dated May 12, 1942.

Copy forwarded to :--

1. The D.C. I/C Kumaon Div. Naini Tal.
2. The Chairman, Municipal Board, Naini Tal.
3. The Superintending Engineer, P.H.D., Lucknow
4. The Superintending Engineer, II Circle, Provincial Works, Lucknow
5. Mr. J.B. Auden, Geologist, Geological Survey of India C/O S.E. High Dams, 89 Ferozepur Road, Ichhra, Lahore, Punjab
6. The Executive Engineer, Kumaon Provincial Division.

for information.

By order,

H. Dannett
Assistant Secretary.

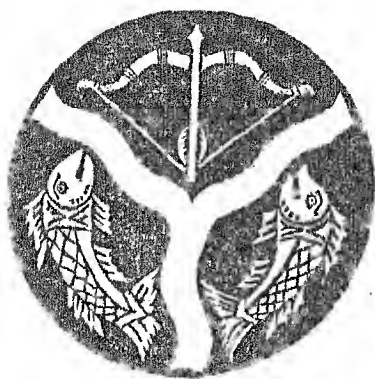


REPORT
ON THE
SAFETY OF CERTAIN AREAS
IN
NAINI TAL
1939

BY
A. L. COULSON, D.Sc., D.I.C., F.G.S., F.N.I.,
Superintending Geologist, Geological Survey of India

LUCKNOW

PRINTED BY THE ASSISTANT SUPDT.-IN-CHARGE, GOVT. BRANCH PRESS
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REPORT ON THE SAFETY OF CERTAIN AREAS IN NAINI TAL, 1939.

I.—Introductory Notes.

When I was in Naini Tal investigating the question of the diversion of the pipe-line of the Naini Tal Municipal Board's Hydro-electric scheme for the Government of the United Provinces in the Municipal Department, I was informed by Mr. L. B. Gilbert, Chief Engineer, Buildings and Roads Branch, Public Works Department, United Provinces, that he was approaching the Director of the Geological Survey of India with a view to the utilization of my services, on my completion of the above investigation, in connexion with the safety of certain areas on Sher-ka-Danda Hill in Naini Tal, about which considerable anxiety was being felt on account of the recent aggravation of certain cracks, more particularly in the grounds of the Philander Smith College.

The Director of the Geological Survey of India duly agreed to my taking up this new investigation and, accordingly, I was occupied on June 6 and 7, 1939, and from June 9 to June 14, in examining such of the hillsides of Naini Tal as I deemed necessary to formulate my conclusions upon the points raised by the Public Works Department authorities.

My conclusions with regard to the question of the diversion of the pipe-line were submitted in July, 1939, to the Government of the United Provinces in the Municipal Department in the form of a report entitled "Geological Report on the Alignment of the Power pipe-line of the Naini Tal Municipal Board's Hydro-electric Scheme". The present report is independent of the former and deals with a different part of Naini Tal. Whereas the July report dealt mainly with the Gangipur and Durgapur spurs, the Ballia ravine and Kalakhan Hill, all of which are to the south of the lake exit as shown in the Naini Tal Guide Map, which forms Plate 1 of this report, the present report for the Public Works Department authorities deals mainly with Sher-ka-Danda Hill to the north-east of the lake, though it also includes notes on other parts of Naini Tal to which my attention was directed.

In my report on the diversion of the pipe-line, I have given rather a lengthy summary of the geology of Naini Tal. As that report will have been read by those who are interested in this report, there seems little point in duplicating that summary. It is sufficient to state here that there are two main series of rocks, dolomites and shales and slates, probably all of Krol age, i.e., most likely Permian. These rocks are intruded by certain dykes and sheets of dioritic trap. To the south-west of the lake on the Ayarpatta side, the rocks are mostly dolomites. Sher-ka-Danda and China, to the north-east and north of the lake respectively, are mainly composed of shales and slates with subordinate dolomites and intrusive traps. The Ballia ravine to the south and south-east of the lake, which was the area chiefly discussed in my July, 1939, report, consists partly of dolomites and partly of shales and slates. The latter seem to pass up into the dolomitic rocks, but the relationships are often obscured by faulting and surface screes.

The conditions affecting the stability of hill-slopes have likewise been discussed in detail in my former report. It is sufficient to recall here that the chief factors affecting the stability of any slope of known inclination are the composition of the constituent rocks, their state of preservation, the direction and inclination of dip and other divisional planes, the variations in sub-aerial conditions to which they are exposed, and finally the liability to earthquake shocks. The only two of these

that can be materially controlled by artificial means are the variations under sub-aerial conditions and the liability to earthquake shocks. Regarding the latter, whilst the *liability* to shocks cannot be decreased, the destructive *effect* of those shocks can greatly be minimized by the construction of suitable buildings on earthquake-proof lines. Regarding the former, as I stated in my July, 1939, report, following Sir Thomas Holland's "Report on the Geological Structure and Stability of the Hill-slopes around Naini Tal", Calcutta (1897)—

"It is obviously necessary to prevent water entering hills in order to prevent the lubrication of the bedding and cleavage planes of the slates. Also the action of water running over the surface, deepening the ravines by erosion and so increasing the angle of slope locally, would, without capacious drains and artificial protective works, prepare the way for the effectual destructive action of subterranean water."

It must also be remembered here that the direction and inclination of the stratification and other great divisional planes is the chief determining factor of the slopes of surfaces and, consequently, of the extent of the more serious rock slides. I have noted that :

"In rocks which have suffered a complete chemical re-arrangement, such as dolomites, the original dip is a consideration of little importance. In slates, the simple effect of the dip-planes is complicated proportionately by the number of joint-planes; and in some parts of Naini Tal the latter are so numerous and so pronounced that slaty rocks must be treated as only a pile of irregular rubbish. The stability of a slope is reduced as the angle of dip approaches the inclination of the surface, and the likelihood and magnitude of a rock slide are very much increased when in a steep slope the rocks dip at a slightly lower angle."

I would recall to the engineers concerned that the average annual rainfall for the 44 years 1895—1938 was 106.09 inches, nearly nine feet of water which has to be got away from the hillsides as quickly as possible in order to prevent it doing damage to them.

II.—History of the present investigation.

At the request of the Principal of the Philander Smith College, Mr. A. E. Eastmond, Executive Engineer, Kumaun Provincial Division, Public Works Department, Naini Tal, inspected the dining hall and assembly room block (known as Laidlaw Hall) on January 29, 1938, and wrote to the Principal as follows on February 5, 1938 :

"The present condition of the block which I understand is named 'LAIDLAW HALL' is *extremely alarming*. This building may in my opinion in its present state hold together for some years but it may, all, or in part, collapse at any time.

I understand that the building was constructed some seven or eight years ago. After about two years the building started to crack and the situation has become worse and worse.

It appeared to me that the building was too heavy for the site. At the time of inspection there were no plans available. The blue print which you have since sent me, only gives the plan of the ground and first floor. It does not give me the depth or nature of the foundations.

I am not asked to criticize the design or workmanship. It was for remedial measures you have asked my advice.

"My first advice was '*not to allow the upstairs for a crowd*'. The building to my mind and without prejudice is a failure.

Some of the buildings may be saved by taking off the top storey and re-erecting the roof over the ground floor.

It seems desirable to me to cut the building into two parts with a gap between the two buildings which we spaced off roughly at site as 30 feet. To do this a new end wall will have to be built (the end near the Principal's office).

I think the Dining Room is larger than required.

It will therefore be necessary to construct the Assembly Hall elsewhere and preferably in some steel construction skeleton. I mention this as a building of this type would in my mind, be more suitable on *doubtful* foundations liable to earthquake shocks and *very exposed* to weather.

I must impress on you that the building as it is, is extremely dangerous. Completely satisfactory remedial proposals are not easy to make where time and financial considerations are limited.

I assume that the Director of Public Instruction has been informed of the condition of the building? If not, he should be now informed at once.

The blue print is returned."

The following fuller report was written by Mr. M. B. Hatfield, who took over the duties of Executive Engineer from Mr. Eastmond later in 1938, and gives details of the remedial measures he recommended for the reconstruction of Laidlaw Hall. Mr. Hatfield's report was accompanied by a plan, a blue print of which forms Plate 2 of this report.

"The Laidlaw Hall was built in 1928 and cost approximately Rs.80,000.

Sometime in 1939, cracks began to appear in the building. In the earthquake of 1934, the south-west part of the building started sinking and since then the sinkage has increased. From an inspection of the building it is evident that the cracks in the building are due to the hillside having subsided. From the levels taken at site, the subsidence is about 10 inches. There is a diagonal crack across the ground floor which is evidently the line of crack of the hill. This is borne out by the cracks in the superstructure as also by disturbance in adjacent retaining walls. Referring to the attached line plan XY is the line of crack. It seems that all the buildings to the north of this line have remained stationary and are intact. There are many cracks in the walls FT and XO, but the portion of the building marked PRDO appears to be in good order and has apparently merely moved downwards 10 inches with the hill.

The subsidence of the hill does not appear to be dangerous, and it is quite possible that very little further subsidence will take place. It would be a pity to dismantle the whole building and rebuild elsewhere, and I would recommend the following alterations being made :

The portions of the building marked PRDO and MLKHVN may be left as they are. The building in between these should be dismantled, and a single storey building erected in its place, the skeleton of which can consist of iron work bolted together. That is, if further subsidence takes place, the iron frame work will to a certain extent be able to move. Again, if it becomes necessary to dismantle this portion, this will be quite easy to do, and the structure could be re-erected on another site. The whole of the upper storey beyond OD should be dismantled as also the first floor. A new hall can be made on the space CTGV. The wall EN need only be dismantled so as to leave it 13 feet high. This also applies to the wall FG. The walls CE and TF will have to be dismantled together as also the superstructure of the verandah to the south-east. The existing first floor consists of concrete on corrugated sheets which rest on cross joists (R.S. joists). The spacing of these joists is the same as the spacing of the roof trusses. They are about 17 feet long, and they could be erected as stanchions (uprights) along TF and CE spaced 8 feet apart, and the dismantled roof could be erected on them. Thus

most of the material would be used. I would suggest that in place of stone walling between CE and TF, asbestos sheeting might be used for closing in the sides but, on further consideration, I don't think that this would look nice and also I anticipate that when the concrete above it is removed many of the sheets will be found to have corroded. I would suggest that whatever sheets are available might be used on the outside of the partition wall CE which faces the hillside. On the inside would be asbestos sheeting (one layer on each side of the R.S. joists). The existing doors and windows can be used again.

I would not recommend a great deal of work being done to the existing floor. It is badly cracked, it is true but were it taken up and re-laid, there is no doubt that it would crack again in the near future. Simple repairs could be effected, so as to make the floor reasonably good. This was explained at site to the Principal.

The drains round the building need repairs. On the upper storey the wall NV is not properly bonded to the wall MN. The corner N will need dismantling and rebuilding so that the walls are properly bonded together.

If desired the flooring of the front verandah can be left and a roof erected over it consisting of a light structure in steel or wood and corrugated iron sheets."

A general statement of the problem on Sher-ka-Danda Hill is contained in the following note by Mr. Hatfield dated June 6, 1939. The plan referred to by Mr. Hatfield in this note forms Plate 3 of this report :

"Hillsides of Naini Tal-Sher-ka-Danda side.

Several slips have occurred on the above hillside, since 1867 and it has generally been recognized that the action of water is the chief cause bringing about slips due to the peculiar formation of the hills around Naini Tal.

Till 1936 the slips and subsidences were generally confined to the area between the drains 18 and 28, shown in red on the plan attached, which has been treated as the dangerous area on this hillside. However, in 1939, 1934, and after the rains of 1937, several cracks were noticed on the southern side of the Laidlaw Hall, a building attached to Philander Smith College. The College compound, as will be clear from the attached plan, just misses the dangerous area line.

During the rains of 1938, the crack line developed resulting in damage to the Laidlaw Hall which has since been rebuilt with a light superstructure. The College building too seems to have subsided *en bloc*. The crack line can be traced from the Dormitory to the playground, but beyond that it is not possible to trace it on account of the thick vegetation on the hillside.

There is no doubt that the hillside is subsiding. It may be local subsidence but on the other hand it is not improbable that the main fissure which was from Alma Gorge to the old Government House compound *via* Snow View and St. Cloud might have extended to the College compound.

In the latter case there are possibilities of its extension further down the ridge as that hillside is mostly denuded and does not differ in its geological formation.

In view of the above, it is obvious that for the safety of the hillside, it should be kept under observation during and after the rains from this year and the usual restrictions in regard to building operations, cutting of trees, etc., applicable to the dangerous areas of the station, be given effect to as soon as possible. This, however, cannot be done unless and until the area is declared unsafe."

The Public Works Department authorities recommend that the area ABCDEFGH, outlined in blue on Plate 3 and lying to the south-east of the present dangerous area of Sher-ka-Danda Hill, be also declared a dangerous area. In this connexion I would refer to the publication of the Public Works Department, Kumaun Division, entitled "Regulations in connexion with Hillside Safety and Lake Control, Naini Tal", published by the Superintendent, Printing and Stationery, United Provinces, in Allahabad in 1932, as the boundaries of the existing declared dangerous area are shown in the plan on scale 10 inches=1 mile which faces that publication.

III. -- Previous reports dealing with Sher-ka-Danda Hill.

Before I can conveniently give a detailed account of my geological observations, it is necessary that one should gain a general idea of the necessity for full account of previous reports. the trouble that has been experienced in the past on Sher-ka-Danda Hill, as, e.g., at the site of old Government House, and give full references to remedial measures that have already been carried out. For this purpose I have quoted rather extensively in this Section from previous reports, more particularly from Holland's standard work on the geological structure and stability of the hill-slopes around Naini Tal, to which reference has already been made in the Introductory Notes. Holland's report was published in Calcutta in 1897 and most work previous to that date has been summarized by him on pages 2--12 of his report. For convenience of reference, the recommendations of the more important committees are given in this section.

According to the 1867 Committee, the so-called landslip of that date above the western bazaar was more of the nature of a rapid scour of a pre-existing ravine than a real landslip.

The same locality was reported upon again by a Committee in 1873 and they recommended the provision of strong cross-retaining walls and the making of a masonry channel to prevent further damage.

R. D. Oldham described the landslip of September 18, 1880, in a note published in *Rec. Geol. Surv. Ind.*, XIII, Part 4, pages 277--281, (1880), and pointed out the essential differences between the south-east and north-west portions of the Sher-ka-Danda slopes. He was concerned with the bulged appearance of the part from Fairlight Hall to Bank House and explained the bulge by surface creep due to the presence of large quantities of water in the surface decomposed rock. He stated that the debris slides slowly down the hill; but it must do so more quickly on the steeper parts than near the bottom of the hill where the slope is less. The debris coming slowly down from above gradually accumulates, causing a bulging towards the base, till the lower part of the slope is so steep that it is touch and go whether the hill can stand or not:

"... then a burst of rain heavier than usual comes, the head of water is increased, the force of the water flowing out near the bottom is increased, it begins to wash away the debris near the bottom till the support being removed from below small slips begin to fall; then a few larger, and finally comes the great slip which brings down the whole crust of half the hillside leaving a precipitous border round that part from which it has come; finally, the great slip is followed by smaller ones, which leave the hill with a pretty uniform slope from top to bottom for the whole process to begin again. Such I believe to be the history of one of these landslips where there is no stream cutting at the base of the hill; where that is the case, slips may be formed at any time by the cutting away of the foot of the slope."

This very graphic description of the origin of landslips should be borne in mind.

The Ramsay Committee of 1880 concluded that at that time there was no danger of further settlement west of Cheena Lodge, or east of Melville Hall; but within these limits, as pointed out by Oldham, the hillside was liable to slip where the slope was greater than 35°. The Committee made extensive recommendations for the safety of the settlement and concluded that the introduction of rainwater into the hill had been greatly facilitated by the destruction of the grassy covering of the slopes by the cutting of roads, sites for houses, gardens and tennis courts, and neglect of drainage.

They also concluded that whilst the action of water had produced numerous cracks and slips so far-reaching as to give the impression of a general and connected movement of the whole hillside, actually no such general subsidence had occurred. The Committee further specified certain sites which they considered to be unsafe.

The Forbes Committee of 1882 found that the remedial measures of the 1850 Forbes Committee, Committee had mostly been carried out and they considered 1882. that the portion of Sher-ka-Danda in question was probably as safe, or safer, than it ever was.

This Committee enquired into the condition of Government House which, at Henslowe Committee, that time, was on Sher-ka-Danda Hill and not on the 1883. Ayarpatta side of the lake as at present. They were of the opinion that the cracks were consequent upon the cyclone of September, 1880; and considered that in the absence of any violent and abnormal disturbance, such as a slip in the vicinity of the building, no material extension of the damage need be apprehended.

In 1888, Mr. F. E. G. Mathews described a number of sites on the southern face of Sher-ka-Danda Hill and showed that movement was F. E. G. Mathews, 1888. not directly towards the lake, but a little more westerly in direction, following the dip of the stratification planes of the slates.

The question of the safety of old Government House was referred to Oldham in 1889, it being stated that slow subsidence appeared to R. D. Oldham, 1889. be going on along the ridge. Oldham concluded that the movement was taking place along some fault or fissure, which runs at a considerable depth through the solid rock. He added :

"There can be no doubt that this is a serious matter, and will ultimately be a source of danger; but no immediate apprehension need be felt, which is fortunate as, owing to the enormous mass which is moving, and the obscurity of the cause to which the movement is due, I can see no prospect of dealing with it successfully."

In 1889, Mr. J. B. Henslowe stated that the fissure could be traced from Government House through St. Cloud to Snow View. He J. B. Henslowe, 1889. agreed with Oldham that the fissure represented no movement of the soil cap, but a distinct separation through the axis of the hill itself. However, he said that the opening of the crack a month or so after the rains was due really to the desiccation following the rainy season. He thought that "at present there is little, if any, movement going on".

Mr. C. H. Holme reported in December, 1890, that the back verandah floor of Murray's shop at the foot of the ridge on which Government C. H. Holme, 1890. House then stood was about one foot higher than the rest of the floors, being "apparently forced up by the pressure of water below".

In his paper on the geology of Naini Tal, published in *Rec. Geol. Surv. Ind.*, XXIII, Part 4, pages 213—234 (1890), C. S. Middlemiss notes (page 214): C. S. Middlemiss, 1890.

"Coming to the practical question as to what geology has to say regarding the safety and permanence of the station and its communications, I hope to be better understood; though on such a subject one is necessarily tongue-tied to a considerable extent. Ever since the disastrous landslips of 1880, the Naini Tal public has been somewhat agitated as to the probability of further landslips, whilst considerable confusion has been introduced into the subject by small slips having occurred now on this side, and now on that side of the lake, and apparently of slate and limestone irrespectively. Now it would not do for me to blacken a hoppe-holder's prospects by proscribing as dangerous any particular site in Naini

Tal. However much I might be able to do so, I should bring a shower of abuse upon myself were I to colour a map of the station showing all the dangerous localities. And yet there would be very little difficulty in so doing. It is merely a problem involving a few factors such as composition of the rock, its whole or shattered condition, the angle of the hill slope, the angle of dip or cleavage, and the relations these four factors hold to one another."

I do not at all hold with this point of view of Middlemiss. The Ramsay Committee of 1880 had already specified certain areas as dangerous, prior to Middlemiss' visit. It is far better for an innocent lessee to realize that he is living in an area liable to slipping, than to keep that knowledge from him for the benefit of the house-owner.

It is instructive to quote at length Middlemiss' description of the area between China and the Bleak House spur, as it is of special interest in view of the nature of the present enquiry. He states (page 224) :

"Leaving China behind us, and continuing down towards the ridge on which Government House stands, we find the slate series constantly with us. As we approach Fairlight Hall, there is to be noticed a gradual change in the direction and amount of the dip of the slates. Instead of being nearly west at low angles it becomes more south-west at 30° and 40° , reaching 60° locally. This change produces a necessary change in the sculpturing of the hillsides. The scarps die out and dip slopes begin to take their place, some of which, south of Fairlight Hall, are very steep and with a convex outline.

At Alma Lodge, in the gap south of Alma Hill, there appears a bed of trap of the same constitution as that found on Ayarpatta. It is 20 yards thick, and dips with the slates 35° south-south-west. Near the junction with the slates it is somewhat slicken-slided. Most probably it is intruded along the bedding as in the case of the trap of Ayarpatta. Since microscopic sections reveal the identity of the two rocks, the fact of apparent bedding in the two distinct sets of strata is of itself sufficient to prove that the rock is not truly interbedded, but intrusive along the dip planes.

As can be seen from the map, the trap dyke, as we may now call it, extends for a considerable distance in a north-westerly direction, keeping throughout its range in the map to a uniform aspect and thickness. A short distance south-east of Alma Lodge the Sleepy Hollow cross-fault shifts the outcrop of the trap to the south-east face of the hillside, where it may be traced only with difficulty for about $\frac{1}{2}$ a mile on account of the soil and vegetation which clothe the slope to a large extent. It then vanishes according to the nature of its intrusion, or it is cut off by the Deopata fold-fault. Whether there is a subterranean connexion between this final appearance of it on this side of the lake and its appearance on the other side it is impossible to say.

The rest of the way along the hill slope towards the Bleak House spur is over slates exposed with a slightly rolling dip averaging 30° down the hillside. Thus the whole of this part of Naini Tal containing a great number of houses is built upon a dip slope which is so peculiar in respect of the clean sweep that the hill side makes down to the lake, as to have suggested to Mr. H. F. Blanford that it was due to the friction of a glacier. A simpler explanation of this feature is to be found in the circumstance that isolated patches of the massive limestone are still left clinging to the surface of this dip slope, one at Sher-ka-Danda, two more on the ridge between there and the Bleak House spur, and a great number of small ones (too numerous to be represented except diagrammatically on the map) in the vicinity of the Bleak House spur. For a strong-bedded formation like that of the massive limestone which, judging from these isolated fragments, once extended probably in a rugged rocky mass over the surface of these slates, necessarily crumbled away under the action of alternate heat and cold and weathering, and eventually left an almost clean swept surface behind.

I have previously in this paper referred to the cleavage in these slates, and the smashed condition in which they are frequently found. On one part of the hill there is a great cake of superficial rubbish slightly cohering because of the calcareous tufa which is deposited among it, but which still, in the rains, sometimes partially breaks up and scatters fragments of limestone and slate down the hill slope. The surface of the slope here has become convex owing to this accumulation of debris, half arrested by the cementing influence of the carbonate of lime. It does not require the gift of prophecy to recognize this as the site of the next landslip that Naini Tal will have to chronicle. For obvious reasons I do not mention the place more definitely".

I consider that Middlemiss was wrong in not specifying this locality; those living nearby are surely entitled to know if a geologist considers their houses to be threatened by a possible landslip, even if it be not possible to give any idea of when that slip will occur. I further discuss this matter on page 32 of this report.

In January, 1895, Mr. F. Giles reported cracks in the retaining walls behind Ravenswood spur, 1895. the Grand Hotel and found the Bank premises to be settling in all directions, whilst the hillside appeared to be in a more or less unstable condition. Colonel Pulford subsequently considered that the cracks and settlement in the walls of the Allahabad Bank were due to faulty construction of the foundations at the back of the house where, also, no provision was made for carrying away water issuing from a spring. He considered that the retaining walls of the Grand Hotel were in a satisfactory condition and thought that the slight settlement in the front portion of the Ravenswood site to be of no serious import.

It was shown in March, 1895, that a portion of the plinth of old Government Corbett Committee, House had settled down as much as 7 to 10 inches and that 1895. the settlement was accompanied by an outward movement of separation totalling $2\frac{1}{2}$ inches between July, 1890 and January, 1895. A report by Mr. F. O. Oertel showed that a fissure nine inches wide was noted in solid limestone rock met with in a trench dug near the billiard room and a stone dropped down could be heard to strike the sides of the fissure for a few seconds. The Corbett Committee were of the opinion that it would be advisable to vacate Government House during the rains of 1895.

In accordance with the suggestion of the Corbett Committee, a further Com-Beresford Committee, mittee was constituted in 1895 of which Mr. R. D. Oldham 1895. was a member. This Committee agreed with the Corbett Committee that the condition of Government House was unsatisfactory, but gave reasons for regarding the building and its site as safe. In order to protect the House from further deterioration and to minimize the effect of the injury already caused, the Beresford Committee proposed certain remedial measures for the drainage and structure of the building and also a system of accurate measurement for the determination of further subsidence. However, Mr. Oldham disagreed with the rest and considered that (Holland, page 10):

"The site of Government House, apart from the question of the stability of the structure, must already be regarded as unsafe during the rains; and considered that matters had developed so far that the proposals of the Committees, though without objection in themselves, were merely palliative and not curative. He proposed that an adit should be driven into the southern face of the hill at a spot not less than 75 or more than 100 feet directly below Government House."

In a letter, dated June 11, 1895, when giving the reasons why he considered the site of Government House as unsafe during the rains, B. D. Oldham 1895. Mr. Oldham noted;

"The transverse fissuring at the head of the future slip is, however, well marked; my attention was drawn to it in 1889, when I reported that the matter was a serious one, but need not be the cause of immediate apprehension. Had I then any suspicion of the very rapid development which would take place in the next five years, I should have used somewhat different language. Comparing the present condition of this line of fissuring and separation of the hillside with what it was in 1889 and 1890, it seems to me, apart from any other consideration, that the end cannot be deferred for many more years.

Had this hill never been interfered with, I anticipate that there would ultimately have been a large landslide, extending from near the St. Loo Gorge to near Alma; but the hill has been largely interfered with, and the result of this is that events have developed most rapidly and the danger is most pressing at the Government House end of the ridge. Such at least appears to be the case, though there is a possibility that the appearance of greater danger may be due to the greater facility of observation here as compared with the same ridge further west."

On being asked to give an independent opinion, Mr. C. L. Griesbach, then Director of the Geological Survey of India, agreed with Mr. Oldham in recognizing the probability of landslips occurring under Government House; but in the absence of conclusive data, he could not say whether such catastrophes may be looked for within a measureable time or not.

The Government of India sanctioned the acquisition of the Sherwood site and the construction of a new Government House in a letter, dated August 25, 1896.

In 1896, Mr. H. S. Wildeblood constructed five adits on Sher-ka-Danda Hill, near Blythe Cottage, below Springfield, near St. Loo below old Government House, and two near Spring Cottage, on the principle, supported by Mr. R. D. Oldham in the Introduction to Holland's report, of preventing the accumulation of water in the soil cap and the surface decomposed rock.

Much of the foregoing has been extracted from Holland's report of his various visits, his last visit being in June, 1896. As he was the last geologist investigating the hill slopes of Naini Tal prior to my own visit of 1927, I must quote at length certain of his relevant observations.

Discussing the dip of the slates on Sher-ka-Danda, Holland notes (page 25) :

"On the Sher-ka-Danda side the dip is towards the S. W. and W. S. W., as shown on the map. Near Melville Hall, where the strata have been disturbed by a fault, the dips change suddenly to the N. W., which continues for some distance along towards the outlet of the lake, and is accompanied by the exposure of a harder and more splintery set of beds in which dolomitic bands are frequent. On the road to the Depot, however, the softer loose slates, characteristic of the north-western portions of the Sher-ka-Danda slopes, are again exposed, and there also are seen to be dipping towards the W. S. W. and S. W., at angles varying between 23° and 35°."

On page 27 he notes :

"Mr. Oldham is of opinion that the even slope on the south-eastern shore of the lake, near the Ramsay Hospital, is due to a thrust-plane, which is not an uncommon feature in highly-disturbed mountain regions, and has been recognized more definitely elsewhere in the Himalayas. The shales in this particular area are lithologically distinct from those exposed in the hill further north-west, being harder and interbedded with much dolomite, whilst the ravines are more nearly coincident with their direction of strike. Around Dunedin House, Assembly

Cottage, and Kumaun Lodge may be seen large tumbled masses of purple slate and buff-coloured dolomite, which, if cleaned off, would probably be found resting on a surface like that exposed near Buttress Castle, a continuation of the same thrust-plane. This thrust-plane is cut off at Melville Hall by a continuation eastwards of the Ayarpatta fold-fault, which is a very fortunate circumstance for those who hold property on the slopes further to the north-west."

He continues (page 29) :

"Passing around to Alma and Sher-ka-Danda we find the surface slopes to present an average inclination of about 30° . The direction of greatest slope in the western portion crosses the direction of dip of the strata at an angle of about 45° , but, on passing eastwards, the contours curve around and bring the surface slope more nearly coincident with the direction of dip.

On the map I have, for reasons stated in paragraph 88, deeply coloured the portions of the slopes in slate which lie outside a surface inclined at an angle of 37° to the horizon. On the portions of the slate formation sloping towards the lake it is found that just one-third of the entire area lies outside the surface of 37° . It will be noticed that under Government House and in the Ravenswood spur there is a noticeably large area lying outside the 37° plane towards the lower half of the hill, in fact within what I have named in another part of this report (paragraph 120) the *landslip section* of the hill. A further feature of the greatest importance has been revealed by analysis of the cross sections, where it appears that in these bulges the steepest slope is generally near the foot of the bulge—a fact of the greatest significance in connexion with Mr. Oldham's remarks concerning the bulging due to creep of the superficial materials in these slopes."

On page 39, Holland notes :

"Where rocks of two kinds are interbedded, the maximum angle of safety of the slope is determined by that of the weakest constituent. It is on this account that the steep dolomite masses resting on the slates of Sher-ka-Danda, like that above the Lake View Hotel and above Oak Openings, become a perpetual menace to everything below.—Precisely similar remarks apply to the intrusive sheets of trap. The traps themselves are tough stable rocks, but coinciding with the stratification planes, as they do on Sher-ka-Danda, they cannot be considered to increase the safety of the hill. Where, however, they occur as dykes they become ribs of strength, and so at least limit the dimensions of a slip."

Holland's observations of the dip of the slates and shales are of great value (page 41) :

"As the result of some hundreds of determinations made on Sher-ka-Danda, I find that the average dip of the slates is 40° to W. S. W., whilst the direction of greatest slope under Government House, for instance, is towards the S. W. and at the site of the landslip of 1880, towards the S. S. W. In these directions, therefore, the apparent dip of the beds will be less than the true dip, being in fact $37\frac{1}{2}^{\circ}$ in the former and 31° in the latter case. On reference to the analyses of cross-sections, it will be seen that there are a few small portions of the Government House slope over $37\frac{1}{2}^{\circ}$, whilst in the case of the 1880 landslip slope the hill from a height of 250 feet above the lake to its crest averages almost 31° , and in many parts is very much over this angle. I have no doubt that it is at this upper end of the lake, where the contours curve around to the west, and so reduce the apparent dip of the rocks in the direction of the surface slope, that the danger of sliding is increased by the inclination of the dip planes being so reduced as to coincide with, or to be slightly less than, that of the

surface at the same place.—I have no doubt that this peculiar relation between the dip of the rocks and the direction of the surface slope, which has been brought out with the aid of the new contoured map, indicates the reason why the serious land slips in 1867 and 1880 occurred at the upper end of the lake, although the slopes under Government House and further south-east may have been quite as steep.

The most complete and striking proof that the direction of the stratification planes do determine the slope is obtained by a comparison of the northern with the southern slopes of Sher-ka-Danda. On passing through the St. Loo Gorge the comparatively gentle slope to Naini Tal, towards which the slates dip, stands in remarkable contrast to the precipitous cliffs shown by the hill at the back of Government House, where the edges of the strata are exposed. The same thing is true of the southern and northern slopes of Alma Hill."

On page 44, he states :

"Towards the north-western corner of the valley on the Sher-ka-Danda side, where, as already mentioned, the contours trend around to the west, the ravines, which, of course, approximately coincide with the direction of greatest surface slope, cross the line of true dip at angles up to as much as 45° . As is invariably the case where a river crosses the dip of stratified rocks, we should expect the slopes on the eastern (south-eastern) banks of the ravine to be gentler than those on the western (south-western) banks. Rosemond's ravine is a very striking example of this fact. If now, as Mr. Oldham has so often stated since writing his paper in 1880, there is a continual creep down the hillside, it naturally follows that this creep, instead of being *directly* down the slope, would take the direction of a resultant somewhere between the direction of the maximum surface slope and that of the true dip of the stratified rocks. Consequently a house built on the western bank of a ravine might be safer than one on the eastern bank, although the latter is on a very much gentler slope.—Alma House, built in 1864, and Alma Cottage, built in 1846, on the precipitous western bank of the ravine have only shown the usual effects of old age, whilst St. Cloud (1874), Snow View (1867), Brae House (1863), and Brae Side (1846, 1872 and 1875), built on the gentler slope of the eastern bank, have been cracked and show a movement westwards towards therefore the direction of dip.

In the face of all these facts there can be no question about the fact that, notwithstanding the severe jointing which the slates of Naini Tal have suffered, the original bedding planes are sufficiently well pronounced to determine the direction of the sliding movement on steep slopes and the direction also of the underground drainage. This being so, it is ridiculous to say that the cracks in all the structures built on Sher-ka-Danda, and, for example, in Government House itself, running parallel to the strike of the rocks, are due merely to superficial settlement. They are unquestionably indications, and only partial indications, too, of movements which have been going on in the rocks themselves—movements of a decidedly serious nature."

Regarding the 1880 slip, Holland observes (page 46) :

"Whilst there is no doubt that water was the chief agent in reducing the stability of the hill to a dangerous limit, it is possible, of course, that the actual slip of the weakest portion of the slope under old Government House was precipitated by the small earthquake shocks, which probably *did* occur at the time of the catastrophe."

Discussing the premonitory symptoms of slips, Holland states (page 51) that abundant warning were given before the 1880 slip, although they were only partially recognized and their import practically neglected. Referring to the serious cracks that developed at the same time in the Ravenswood spur, he states (page 52) :

"The most natural inference as to the origin of these serious cracks, extending for such great distances parallel to the strike of the rocks and in the upper

portions of the slope, is that there has been a distinct movement towards the lake of the lower portions of the hill, and, taken in connexion with the undoubted bulge towards the foot of the slope, they can only be regarded as premonitory symptoms of a movement, which, if permitted to continue, will culminate in a disastrous landslip."

Holland agreed with Oldham in recognizing that there was evidence of lateral shearing in the ravine between St. Loo and the Staff House.

He states (page 55) that the value of adits in removing subterranean water would naturally be accentuated in wide spurs.

"As the dip of the strata is more westerly than the direction of greatest slope, the rocks naturally carry the water obliquely across the spur, and are relieved by springs on the eastern banks of ravines. The narrower the spurs, therefore, the easier the internal drainage; and, other things being equal, a narrow spur such as that upon which Edgehill stands is safer than a wide one like Ravenswood."

He mentions springs occurring in the ravine due south of Tonnochy's, and from under Glommore, Springfield, Oak Lodge, Edgehill and Spring Cottage (page 56):

"All these springs are situated at points where the deeper water-carrying strata are brought to the surface by an increase in the surface slope; and it naturally follows that an artificial addition to such natural relief must increase the frictional stability of the hill above besides preventing the soaking of so much water into the portions of the hill below."

He adds that, on account of the high angle of dip, adits constructed below the steep bulges on the parts of Sher-ka-Danda south-east of Edgehill spur would be of little practical advantage in removing water carried along the stratification planes of the undecomposed rock. He also rejects the steep bulge west of Charlton Lodge as the site of an efficient adit, as the results would be out of proportion to the cost. The same is true of the Ravenswood spur, which also receives a large quantity of water, but cannot be relieved efficiently by adits. However he suggested the construction of an adit in the area of low dips under Government House, and this was done.

Finally one of the selected sites described by Holland was Government House and the Edgehill spur. This is very important in the light of the present investigation and his remarks are quoted extensively (page 61):

"As the spur on which Government House stands runs about south-west, and the dip is to west-south-west, the movement will not be directly down the slope, but obliquely across. As a result of this fact, the movements of the rocks immediately under Government House would not necessarily be connected with the movements of those under Edgehill, and an examination of the cross-section no. 8 immediately confirms this view. . . . The stratification planes immediately under Government House are inclined at a lower angle than the slope of the surface, whilst in the bulge on which Edgehill stands, the strata stand at a higher angle than the surface; . . .

There is, therefore, a moveable mass of strata under Government House, which is in the form of a 6°-wedge, having a length of 400 feet. It is the gradual creep of this wedge, from causes explained in paragraphs 79-82, which produces the cracks parallel to the strike of the strata through Government House, and I should expect that the large fissure known to exist under Government House extends vertically down to this gliding plane, which cannot be more than about 50 feet below the foundations of the house. That this wedge will rapidly slide off like an ordinary landslip is not possible, as long as it is kept dry, and careful

drainage might even arrest much, or practically the whole, of the creeping movement, whose differential effects are endangering the structural stability of the house above. Although rock-falls may occur from any part of a steep hill, a hill of slate, such as we are dealing with in this instance, would hardly, if exposed to the ordinary action of weather, give a serious rock *slide* from near the watershed. For reasons which need not be detailed here, serious landslips occur generally near the base of the slate hills (the *landslip section*), and seldom extend more than half-way up, as was the case with the landslips of 1867 and 1880 in Naini Tal.

As to the stability of Government House *per se*, the Engineers, who are acquainted with the history of its construction, are the only qualified judges; but with regard to the particular portion of the hill upon which it stands, there seems to me to be no possibility, as long as the drainage works are kept in order, of anything approaching a landslip. As long as Edgehill and Ravenswood stand, the hill under Government House is, I consider, absolutely safe. Even if Edgehill should slide down into the lake, the foundations of Government House will be no more affected than those of St. Cloud were by the landslip of 1880, and until that catastrophe takes place, the only source of danger will be due to the damage done to the foundations of the house by the slow differential movement that has unquestionably been going on for some time all along Sher-ka-Danda."

The above quotation is very important as it gives Holland's views regarding the stability of the spur upon which old Government House was built.

Mr. R. D. Oldham in his introduction to Holland's report (page vii) sounded R. D. Oldham, 1897. a note of warning in this connexion and stated :

"The second passage is in paragraph 120 which might be misread to produce a false feeling of security. It is true that landslips starting from the crest of a hill, such as Sher-ka-Danda, are exceptional, but they do occur and, within my own experience, I have seen more than one in other parts of the Himalayas. In the present case the natural conditions have been modified by extensive cutting away of the top of the hill, and the symptoms it shows are those which are recognized as premonitory of a free landslip. In these circumstances it is, to say the least, wiser to adopt those curative measures indicated by the symptoms rather than await the fatal termination of the disease under a suspicion that it may have been wrongly diagnosed."

In his report on the Kalakhan landslip of August 17, 1898, Mr. C. S. Middlemiss did not specially treat with any area of Sher-ka-Danda, but confined his remarks to Kalakhan.
C. S. Middlemiss, 1898.

Old Government House was kept under observation from 1895 to 1899 and weekly reports were submitted on the development of cracks. It was decided by a Committee of Engineers which met in October, 1899, to dismantle old Government House and to use the materials elsewhere, as the measurements seemed to show that the cracks were getting worse and worse and the house more and more dangerous. It was considered, however, that the staff quarters attached to Government House, being situated behind the main fissure, were safe. Nevertheless, it would appear from plan 2, showing the cracks in Government House on February 1, 1895, which plan faces page 67 of the "Collection of papers regarding the stability of Old Government House at Naini Tal", that a crack actually traversed the staff quarters. The old staff quarters are at present used as a P. W. D. Inspection Bungalow. New Government House on the Sherwood site was completed in 1900.
1899 Committee.

The Berthoud Committee of 1907 examined very carefully the whole of Sher-ka-Danda included in what was known as the prohibited area, between Melville Hall and Cheena Lodge. In their report, this Committee give a lengthy summary of previous work and also the
Berthoud Committee, 1907.

results of measurements of the fissure through the former site of old Government House, as observed by pillars built in 1895 after the Beresford Committee. They noted that the opening of the fissure increased the further west one goes and was largest west of Snow View. The total horizontal movement, however, was small; and in the 12 years preceding 1907, the recorded movements of the four pairs of pillars totalled 1.56, 1.56, 3.06 and 7.37 inches. There was no tendency for the movement to become worse. They also gave tables of settlement observed in the St. Loo grounds and along the depression east of the Edgell ravine on the Middle China Mall, and stated that no appreciable differential movement was recorded at either place during the previous five years. The Committee considered the results very reassuring. They then commented on the results of theodolite observations of pillars from Jesmond Villa and Tonnochy House. The Jesmond Villa readings showed a forward movement of two stations on Ravenswood spur of 51 and 52 inches in 12 years; and three pillars on the Edgell spur moved 42, 44 and 36 inches towards the lake during the same period. Oak Openings and Ramsay Hospital showed a forward movement of 29 and 30 inches in the 12 years before 1907. The observations from Tonnochy House also showed that the whole of Sher-ka-Danda had moved bodily forward 9 to 17 inches in the same period. The Committee concluded that as long as the Edgell and Ravenswood spurs showed no greater forward movement, no apprehensions need be felt regarding their safety.

The Berthoud Committee made numerous comments and many suggestions concerning the drainage of Sher-ka-Danda and concluded that their examination

"was sufficient to show that under ordinary conditions apprehension need not be felt at present for the safety of the Sher-ka-Danda hill; and that although movements are no doubt going on, if the above measures are accepted, timely warning will be given of any impending danger. However, to ensure that a careful watch is kept, the Committee would suggest that the condition of the hillsides be regularly reported on by a special committee at intervals of not more than three years."

In the annual report on the hillsides of Naini Tal for 1925, Mr. S. G. Edgar drew attention to the low figures obtained for the percentage run-off of the rainfall and stated:

"In the history of the settlement there have been occasions when garden terraces have been sloped off, tennis courts in certain localities have been rendered impervious by clay covering; gutters to all houses in certain areas have been insisted upon and at one time there was a four-acre minimum area assigned to a bungalow compound. Most of these methods are now not attended to and I believe some of them have been set aside officially."

The trend of the times is undoubtedly to ignore the recommendations of the older generation of engineers, geologists, and others who made Naini Tal the popular hill resort it is, but taking last year's percentage discharge as accurate for the purpose of argument it seems to me for the short experience I have had of the division that matters have gone far enough. The percentage discharge is in my opinion the index figure of the safety of the settlement and even while questioning its accuracy I would regard any further decrease as of ominous portent."

I refer later to Mr. Edgar's other conclusions.

In spite of the recommendation of the Berthoud Committee of 1907, the next Dobbs Committee, Committee on the hillsides of Naini Tal did not meet until 1927. This Committee, of which I was a member, was not particularly concerned with Sher-ka-Danda Hill, but some of its

recommendations dealt with individual cases on that hill. Thus it was recommended that the tennis court at Fairlight Hall should be sloped off or provided with a rammed clay foundation; also the provision of adequate drainage above Maldon Cottage was suggested, with the possible sloping off of the vegetable garden at St. Cloud Cottage. It also reported that the existing protective works were adequately maintained and served the purpose for which they were constructed.

In my separate geological report, which was published in Lucknow in 1928, I noted with regard to Sher-ka-Danda Hill:
A. L. Coulson, 1928.

"Mr. Edgar's general conclusions in his note are agreed with. There appears to be an undoubted annual movement on practically all the spurs. It is not considered necessary to discuss the nature of the individual spurs as Sir Thomas Holland has already described the geological conditions of these, and his report may be referred to. One can but reiterate the warning that the drainage of the area is extremely important and should have special care. In this connexion it might perhaps be pointed out that the drainage of the area above Maldon Cottage is not considered adequate and free access into the Charlton Lodge spur is given to much water. An inspection should be made of St. Cloud Cottage, Brae Side, Brae House and the houses to the east of these.

Again the spur from Fairlight Hall to St. Helens and Blythe Cottage is far from safe and it is for consideration whether or not the tennis court at the first-named house should be allowed in view of the catastrophic effects of a slip in this region.

The Edgehill and Ravenswood spurs should be carefully watched for any premonitory signs of a big slip.

The general location of the pillars is good and it is recommended that the present system of recording the annual movements be kept up."

The 1937 Committee was the last one that has discussed the safety of the Naini Tal area and it was concerned mostly with the lake.
1937 Committee. It noted that the

"Municipal Board have not given effect to the proposal to slope off the tennis court at Fairlight Hall or provide it with a rammed clay foundation. This Committee considers that the danger pointed out by the 1927 Committee still exists, and that the action recommended by that Committee should be taken."

They also noted:

"Adequate drainage has been provided above Maldon Cottage; a new drain was built in 1927 at the cost of Rs. 2,000 and is serving its purpose. But the Municipal Board have not had the vegetable garden at St. Cloud sloped off as suggested. This should be done."

In my July, 1939, report, I have discussed the views of the 1937 Committee with regard to the question of percentage run-off.

The 1937 Committee noted that there had been very little movement in the hillsides in the lake area since 1927; and that movement generally had been less than during the previous ten years.

IV.—Movements of Pillars and Marks on Sher-ka-Danda Hill,

Table I, which follows, contains figures for the movements in different spurs within the lake area as given in Appendix F of the 1937 Committee's Report.

TABLE I.—*Movements in inches of pillars in different spurs and localities in the lake area of Naini Tal in ten-year periods, 1917—1926 and 1927—1936 (inclusive).*

Locality	Total maximum movements			
	1917—1926		1927—1936	
	Horizontal	Vertical	Horizontal	Vertical
Main fissure, Sher-ka-Danda : Lala Durga Sah's tennis court.	2.17	2.64	3.09	0.72
Main fissure, Sher-ka-Danda : St. Cloud.	3.25	1.68	1.06	1.44
Main fissure, Sher-ka-Danda : Snow View.	4.34	4.80	1.96	1.76
Main fissure, Sher-ka-Danda : Old Government House.	0.62	1.08	0.86	1.20
Edgehill spur	13.82	Not recorded.	7.05	Not recorded.
Ravenswood spur	23.46	Do.	6.74	Do.
Blythe Cottage spur	5.06	Do.	0.65	Do.
Alma spur	13.82	Do.	8.05	Do.

In Tables II to V, which follow, I give the movements of pillars and marks on certain spurs on Sher-ka-Danda during the last 11 years.

TABLE II.—*Movements in inches between pairs of pillars along the main fissure on Sher-ka-Danda Hill during the years 1928 to 1938 (inclusive).*

Pairs of pillars. Direction of movement		A—B		C—D		E—F		G—H		B—I		D—J		K—L	
		Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.
Year															
1928	...	0.10	0.22	0.24	0.10	0.11	0.01	0.49	0.04	0.03	0.12	...	...	0.25	0.01
1929	...	0.10	0.01	0.10	0.02	0.04	0.02	0.10	0.02	0.03	0.01	...	...	0.12	0.01
1930	...	0.07	0.01	...	...	0.05	0.01	0.07	0.01	0.05	...	0.10	0.02	...	...
1931	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1932	...	...	0.12	...	...	0.12	0.24	0.06	...	...	...	0.12	0.12	...	0.12
1933	...	0.25	0.24	...	...	0.25	0.24	0.37	0.12	...	...	...	...	0.37	...
1934	...	...	0.24	0.37	0.36	0.25	0.24	0.62	0.24	...	...	0.25	0.24	...	0.24
1935	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1936	...	0.12	...	0.12	0.24	...	...	...	0.24	...	...	...	...	...	...
1937	...	0.12	0.48	0.25	...	0.37	0.12	0.50	0.60	0.12	0.12	...	...	...	0.12
1938	...	...	0.24	...	...	...	...	0.50	0.36	...	...	...	...	...	0.12
Total movement in last 11 years.		0.76	1.56	1.08	0.72	1.19	0.88	2.71	1.63	0.23	0.25	0.47	0.38	0.72	0.60

Pillars A, B, C, D, I and J are on Lala Durga Sah's tennis court.

Pillars E and F are at St. Cloud.

Pillars G and H are at Snow View.

Pillars K and L are on the flat at old Government House.

TABLE V.—*Movements in inches of pillars and marks on Sher-ka-Danda Hill as observed by theodolite from Jesmond Villa from 1928 to 1938 (inclusive).*

Station observed	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	Total movement in years
Oak Openings iron rod
Pillar 5, Edgehill	...	4.26	...	1.41	...	...	...	...	...	...	...	5.6
Pillar 6, Edgehill spur	1.38	2.76	...	...	...	...	...	...	2.76	6.9
Pillar 7, Edgehill spur	1.42	...	...	...	...	...	...	...	2.82	4.2
Ravenswood outhouses	2.76	2.76
Pillar 8, Ravenswood	1.65	...	...	...	...	...	...	...	3.30	4.95
Ramsay Hospital spire
Pillar, Alma spur	3.11	...	...	...	...	3.11
Pillar, Blythe Cottage spur	0.64	...	...	...	2.55	...	...	...	...	3.19

It will be seen that the greatest movement of pillars and marks took place in the years 1929 and 1938. No movement was recorded in 1933, one of the two years in which greatest movement took place in the St. Leo and Edgehill depressions.

It is interesting to note that there is no correspondence between movements of these pillars and marks and years of heavy rainfall. To my mind, this seems to indicate that the drainage of those spurs on which most of the pillars and marks are situated, is in good order.

We are particularly interested in the recorded movement of the mark on Oak Openings, the residence of the Principal of the Philander Smith College. Whilst no movement has been recorded from the Jesmond Villa Observatory Station, movement was recorded from the Tonnochy House observatory during the years 1929 and 1931; but none since then. It is obvious that the mark observed here is far more stable than the rest of the building, as will be made clear in the description of the damage done here by differential subsidence within recent years. Accordingly the observation of the mark on Oak Openings from either observatory so far seems to have had but little value.

In future more information will be available regarding the movements taking place in and under the College grounds. The Public Works Department authorities have erected eight pegs on either side of the chief cracks through the College grounds: two in front of the Dormitory, two near the south-east corner of Laidlaw Hall, two in front of the Playroom, and two on the Sports Field. They are arranging for measurements of the distances between each pair of pegs to be taken regularly during the present rainy season.

The Public Works Department have also erected six pillars on the spur on which Laidlaw Hall is situated, the pillars being placed as follows: the lowest above the tennis court of Jakhwal Sadan, above the Middle China Mall; the next at the toe of the steep slope above the Middle China Mall; the third at the top of the steep slope above the Middle China Mall; the fourth just above the Upper China Mall; the fifth on the road to the College Sports Field, just below Laidlaw Hall and above the Upper China Mall; and the sixth, sited on my suggestion, on shales *in situ* above the water tanks on the spur of Sher-ka-Danda Hill above the Laidlaw Hall. Pillars 1 to 5 of these 6 will thus be aligned along the cross-section of Sher-ka-Danda Hill through Laidlaw Hall which forms Plate 4 of this report. The movements of the six pillars will be observed by theodolite from either Jesmond Villa (or Brook Hill House) or Tonnochy House, whichever is convenient.

V.—Geological observations and recommendations regarding Sher-ka-Danda Hill.

1. General.

The chief part of Sher-ka-Danda Hill concerning which most anxiety is felt by the engineers concerned at the present moment is the Importance of present investigation. Philander Smith College grounds. The location of these and the buildings therein are shown in Plate 1 and also Plate 3 of this report. It will be seen that the grounds of the College extend from near the St. Loo Gorge south-eastwards under the summit of Sher-ka-Danda and then on the crest of the ridge further to the south-east. So if the safety of all buildings in the College is under discussion, this perforce involves the safety of most of the houses on the lower slopes of Sher-ka-Danda from the Naini Tal Bank to St. Francis' Church. When we realize, also, that the fissures that have developed in the grounds of the College are more or less in continuity with the old main fissure of Sher-ka-Danda Hill, running north-west on the other side of the St. Loo Gorge towards Tonnochy House, the potential danger of which has long been recognized, the importance of the present investigation and the great interests at stake can easily be gauged. Such being the case, no apology is needed for the length of Section III, which has given fairly and accurately the views that have been held in the past concerning the safety of Sher-ka-Danda Hill. The length of this Section V must also be excused upon the same grounds.

For reasons of convenience and to facilitate reference, such recommendations that I consider essential for the safety of various parts of Sher-ka-Danda Hill have been given after the descriptions of the buildings and sites in question.

2. Oak Openings to Ramsay Hospital and the area above and below.

It may be stated at the beginning of this description of the buildings in the grounds of the Philander Smith College, which are very extensive and form a large part of the area described in this sub-section 2, that I consider the College authorities themselves are fundamentally to blame for much of the present and past unsatisfactory state of their buildings by their neglect to take simple precautions in respect of the drainage of their buildings and grounds. Most of the large buildings are far too heavy for the sites upon which they are constructed. Possibly the neglect of drainage has been caused by financial considerations, but I shall discuss that point later. Suffice it to be said here that I consider the drainage of the College grounds to be a matter of the gravest importance, not only for the College authorities themselves, but also in the interests of the safety of all houses and other structures erected on the lower slopes of Sher-ka-Danda beneath the College grounds.

The chief buildings in the College grounds lie roughly in a line running south-east from Oak Openings, the residence of the Principal. To the north-west of Oak Openings are the Philander Smith Tennis Courts, on the hillside of which is a fairly recently renovated building used as a Kindergarten. The drainage of this little building discharges on to the Tennis Courts, which themselves are undrained. The Kindergarten building is slightly cracked in its southern wall. On the hillside of the building and behind Oak Openings are terraces of vegetable gardens.

Recommendation 1.—The Tennis Courts north-west of Oak Openings should be thoroughly drained and arrangements made for the removal of the drainage of the Kindergarten. If they are not already so provided, the Tennis Courts should have rammed clay foundations.

Recommendation 2.—I would advise the sloping off of the vegetable gardens behind the Kindergarten building and Oak Openings. I realize the dependence of the College authorities upon home-grown vegetables; but where the continuance of vegetable gardens must have its repercussions upon the stability of the buildings erected beneath them, and consequently contribute to the necessity of spending money on repairs to buildings, it is for very serious consideration whether or not the saving in home-grown vegetables is counterbalanced by the repair bill.

Recommendation 3.—The path leading to the Philander Smith Tennis Courts is badly in need of drainage facilities.

Oak Openings has been badly cracked for a long time and the cracking has recently been aggravated. The building is a two-storeyed one, showing cracks running longitudinally through it from north-west to south-east. I have already (page 18) commented upon the movement, or lack of it, of the mark on the northern wall of Oak Openings. The front plinth of the building has subsided several inches and the removal of carpets in various rooms showed evidence of serious subsidence within recent years. Large cracks are visible on most north-east-south-west-trending walls; these are plastered over from year to year, but invariably the movement continues and the cracks open up afresh. The subsidence appears to be directed downhill, i.e., towards the south-west. At present the front part of the upper storey is definitely unsafe. The drainage at the back (hill side) of the building is in fair condition, but could be improved.

Recommendation 4.—I would suggest that the front portion at least of the upper storey of Oak Openings be dismantled and the building here made single-storeyed. There is little doubt that the building as it stands is too heavy for the site. If they adopt the very numerous other recommendations that I make in this report, it is possible that it will be beyond the means of the College authorities to pull down the whole of Oak Openings; but when the question of re-building comes up, and I think it should really be considered now, then it must be borne in mind that it is essential to have a light structure on this site.

The two-storeyed disused class room to the south-east of Oak Openings is likewise badly cracked, though this does not show very much inside on account of the lining boards. However, taking into consideration with the outside cracks on the building, there seems little doubt that the partings visible in many places inside between the lining boards is presumptive evidence of differential subsidence. There are several cross cracks in the lintels of windows facing south-west. The front verandah appears to have moved fairly recently an inch or more in places away from the building in a south-west direction, i.e., downhill.

Any reduction of the weight on this part of the spur will have an advantageous effect upon the stability of the Oak Openings building. There is no doubt that there are definite cracks running from the Tennis Courts, through Oak Openings and the disused class room. I shall give reasons later for believing that these cracks, if not continuous with those running from the St. Loo Gorge to the north-west, are at least parallel to, and connected in origin with, them.

Recommendation 5.—If this disused class room is no longer required, I suggest it be demolished and the materials used elsewhere.

The sites of Oak Openings and the disused class room are far from ideal inasmuch as there are large masses of dolomite, certainly mostly *in situ* higher up but lower are loose blocks, above both buildings. We may remember here Holland's remarks regarding the stability of hillsides composed of rocks of two kinds (*see* page 10 of this report), and recollect that the stability of the underlying slates is the determining factor. The outcrop of dolomite above the buildings is shown on the map accompanying Holland's report.

Recommendation 6.—There is a badly cracked outhouse behind the old class room, which should have its drainage attended to. At present it has practically none. The question of its structural safety may be considered.

The old Isolation Hospital, situated to the south-east of the old class room but higher up the spur, is very badly cracked and no drainage worth the name.

Recommendation 7.—Though there are no cracks in the building later than the last white-washing, the building and its drainage certainly need much attention; or else the building, which is only inhabited from time to time, should be demolished and the ground sloped off. In addition, the disused garden and slopes beneath it, upon which clothes are spread to dry, should certainly be sloped off and be the subject of considerable attention with regard to their drainage. The cracks through this building are apparently continuous with those through the Laidlaw Hall and a connexion can be traced during the monsoon months.

I have mentioned on page 18 the two water tanks used as a reservoir for the college above which I suggested locating an observation pillar. Here the shales are *in situ* and seem to dip at 30° to the W. N. W. The dolomite exposure referred to previously ends just above the tanks to the north-east. A glance at Holland's map shows the possibility of a cross-fault here, striking N. E.—S. W., somewhat along the line of the continuation of the Ayarpatta fold-fault. There does not seem to have been movement parallel to this cross-fault as most of the cracks that have appeared in the College grounds run N. W.—S. E. and N. N. E.—S. S. W., approximately in the direction of strike of the shales and slates.

The present so-called dangerous area on Sher-ka-Danda Hill is limited to the south-east by drain 13, as shown on plate 3. The buildings in the College grounds that I have already discussed lie within the limits of the present dangerous area; but those I now discuss, the Dormitory, Laidlaw Hall, Class room, and the Playground and Sports Field, lie without that area.

The covered pathway from the old Class room to the Dormitory from time to time shows evidence of differential movement, more plainly during the rains. The alignment of the roof, however, is sufficient evidence of its chequered career.

Recommendation 8.—The drainage of the covered pathway needs considerable attention and small tributary drains could be made to join up with drain 13. The drainage of all outhouses below the pathway is either defective or non-existent.

There is a large depression of at least $1\frac{1}{2}$ feet in front of the north-west end of the main Dormitory, built in 1926, which is practically continuous through the covered pathway with the cracking in the old Class room and Oak Openings. The Dormitory itself is a heavy two-storeyed building, which luckily so far seems to have escaped serious damage. It is set back sufficiently far to have escaped differential movement on account of the depression of the ground at its north-west end. There is certainly cracking visible in the south-eastern wall; but at present it is very small in amount. Both Mr. Hatfield and I are in some doubt as to whether this cracking can definitely be ascribed to the general fissuring; but personally I feel it should be in part at least so ascribed.

Recommendation 9.—The drainage of the Dormitory needs some slight attention and it is certainly advisable that its site should be properly drained.

Recommendation 10.—The movements of the piers on either side of the main fissure at the north-west end of the Dormitory (see page 18) should be carefully watched. I think that the Dormitory is too heavy for the site and I fear that the cracking in the building may continue in spite of all precautions. However, it is to be hoped that I shall not be correct in my forecast of possible further subsidence here.

We now come to Laidlaw Hall, the building that has suffered most through differential movement due to fissuring of the ground and rocks beneath it. An account of the damage done and remedial measures taken has already been given in Section II of this report. Mr. Hatfield's plan, a blue print of which forms Plate 2 of this report, shows the alignment of the main fissuring through the building which was roughly east and west but trending more N. W.-S. E. through the verandah. The subsidence of the plinth of the building is well shown in the plan, the level in the west corner (the building trends N. E.-S. W.) being 9.54 feet; whereas the plinth level of the western side next the kitchen was measured as 10.63 feet, a difference of 1.09 feet. Since the reconstruction of the building on the lines suggested by Mr. Eastmond and Mr. Hatfield and carried out under the supervision of the latter gentleman, there has been no further subsidence. There is little doubt that it is essential that the building should be single-storeyed in its central part over the fissure area, and one can but hope that the weight here has been reduced sufficiently to give the rocks beneath a chance to heal.

However that may be, it is certain that the fissuring was not merely in the surface soil, but extended down to the shales and slates beneath. Thus in the hillside facing the west side of the building, opposite the new single-storeyed reconstructed building, there is definite cracking and fissuring in the highly jointed shales along one of the major joint-planes. The shales here dip at 30° to the W. N. W. and the fracture line strikes a little east of north and "dips" at 45° to a little north of west. The fracturing here was thus along no constant direction, as in the case of the Oak Openings fissuring. This is probably due to the nearby presence of the cross-fault to which reference was made on page 21. However, beyond Laidlaw Hall, the fissuring seems to have a general south to south-easterly trend, through the class room, playground and sports field.

There is much cracking in the hillside against the kitchen at the back of the Laidlaw Hall and the hillside here seems far from safe. It is possible that the fissuring through Laidlaw Hall joins up with that through the path to the old Isolation Hospital, a connexion having been traced during the rains as stated upon page 21. This fissuring must be considered as different from that through Oak Openings and the covered pathway to the front of the Dormitory, but it is roughly parallel to it, except during its course through Laidlaw Hall, and a short distance to the east.

Recommendation 11.—Considerable attention should be given to the cliffs above the kitchen part of the Laidlaw Hall. Some of the pupils of the College were noted sheltering under the cliffs which are formed of very shattered and fissured rocks liable to rainfall especially during the rains. Some of the shattered material could be removed at small cost, but care should be taken not to disturb the hillside more than is necessary.

Recommendation 12.—The rebuilding of the central part of Laidlaw Hall appears to have been carried out efficiently under Mr. Hatfield's supervision; and when we visited it, it showed no further signs of cracking, at least in the rebuilt portion. However, there are old cracks in the bathroom of the office part in the west corner of the building, and it is advisable to have tell-tales put across the cracks and observations taken. If the movement continues here, it may eventually be necessary to reconstruct the office also as a single-storeyed building.

The next large building of the College below the Laidlaw Hall is the present class room, a heavy two-storeyed building at present in a most dangerous and unsafe condition. It is cracked longitudinally from N. N. W., to S. S. E., and practically all the E. N. E.—trending walls show cracking. In addition the flooring boards along the upstairs passage through the middle of the building have parted and gaps are visible between them. There is an undoubted subsidence of the west part of the building downhill, i.e., to the W. S. W. This subsidence is particularly visible in the large room upstairs at the S. S. E. end of the building. Certain of the arches of the windows, especially those in W. S. W.—trending wall at the N. N. W. end of the building, have cracked so badly that it would appear that it needs but a slight earthquake shock for them to fall.

Recommendation 13.—In the interests of the safety of the pupils of the College using the class room, I consider that this building should be condemned and demolished as soon as possible. Constant movement down the hill appears to be going on here and it is only a matter of time before the building falls to pieces. Running about by a crowd of pupils upstairs might easily set up strains that would have a disastrous effect upon the building in its present weakened state. The drainage of the site and playground around the class room is very bad and needs very considerable attention. However, there seems little point in attending to the drainage of the building, if, as should be insisted upon, the building is demolished immediately. As I have stated, the building is very heavy, far too heavy for the site. If permission be granted to the College authorities to rebuild upon the same site, then a light single-storeyed earthquake-proof structure might be insisted upon. Even a single-storeyed building here has little chance of stability unless and until the drainage is very carefully attended to. It is but a short distance to drain 7 and the drainage should certainly be linked with that drain.

Recommendation 14.—The movements of the two sets of pegs on either side of the main fissure here through the playground should be very-carefully watched. The existence of this crack behind (to the east) and parallel to the one through the classroom does not encourage the idea of rebuilding the classroom further to the east than the present site.

There is a small light building to the north-east of the class room which is used as a playroom for the pupils of the College.

Recommendation 15.—The drainage of the playroom needs some considerable attention.

Recommendation 16.—The movement between the pair of pegs on either side of the fissure through the Sports Field, which is terraced upon the spur to the S. S. E. of the play ground, should likewise be carefully watched. There is evidence of differential movement in the cliff of the Sports Field terrace, and it would appear that this movement is definitely in the shales.

Recommendation 17.—If care is not taken to prevent water entering this known crack which traverses the Sports Field, further movement will undoubtedly take place. Therefore the Sports Field needs to be drained thoroughly. It will be easy to join the drainage with the disused drain at the S. S. E. end of the Sports Field, which eventually discharges to the east side of the Sher-ka-Danda Hill.

The houses and out-houses belonging to the College authorities and situated Silver Oaks and Vale within their grounds below the Laidlaw Hall and the class Head room need considerable attention to their drainage.

Recommendation 18.—The house Silver Oaks inhabited by some of the teaching staff and situated above the Upper China Mall, is built upon the flat portion of the spur below Laidlaw Hall as shown in Plate 4. Even so, it is

cracked though apparently only recently renovated. Its drainage and that of the path leading to Upper China Mall needs attention. Likewise attention could be given to the drainage of Vale Head further to the south-east and the road leading down to the Upper China Mall between the two houses.

It is convenient to discuss here a few sites without the College grounds, but situated on the slopes of Sher-ka-Danda beneath them and further to the south-east. The first is Ratan Cottage, the position of which may be seen in Plate 1. This house seems to have been built only a relatively short time ago, but it and its outhouses are undrained.

Recommendation 19.—It lies just to the south of the unlined portion of drain 6, between the Middle and Upper China Malls. The house should be protected by revetment walls at the back, its vegetable garden should be sloped off, and the drainage of the house and outhouses led to drain 6.

Recommendation 20.—The lined portion of drain 6 ends at the Middle China Mall. There is a good valley crossing the Upper China Mall next to the two eater tanks, which, if continued downwards, would join with drain 6. It might in the past have been considered unnecessary to line drain 6 up to or beyond the Upper China Mall; but conditions have now changed. Rightly or wrongly permission has been given for the construction of Ratan Cottage, but no steps have been taken to give drainage facilities. I suggest that it is eminently desirable that drain 6 should be lined upwards from the Middle China Mall at least to the Upper China Mall. Attention should also be given to the roadside drainage of the Upper China Mall from branch 2 of drain 13 to the upward continuation of drain 6. It might be considered expensive to provide roadside drains for this distance; but if, as I shall propose, the so-called dangerous area is extended from drain 13 to the south, it logically follows that the drainage of the extra area then included in the dangerous area should be carefully attended to. There is already evidence of erosion of the soil cap, consequent upon rainfall after the destruction of the surface vegetation by fires. In the course of time, this problem of the drainage and revetting of the Upper China Mall beyond drain 13 will have to be attended to.

Recommendation 21.—Drain 7 is unlined in the steep portion of its length where it passes over dolomitic material between the Middle and Upper China Malls. This part of drain 7 should be made *pucca*.

Recommendation 22.—Humus-containing soil is being removed for gardening purposes by the servants of nearby houses from the steep portion of the hillside above Middle China Mall, a short distance south of the tennis court of Dunedin. Several places where soil had been removed were noted on either side of a cooly path near drain 8. The owners of the nearby houses should be warned to instruct their *malis* to cease this dangerous practice.

Recommendation 23.—The Tunstall Hall road could with advantage have roadside drains.

There is an eroded portion of the Sher-ka-Danda Hill above drain 2 between Stoneleigh and Ramsay Villa (*see* Plate 1), from which a large boulder of dolomite rolled down in 1937, but luckily came to rest without damage in a branch of drain 2. In 1938 the Public Works Department authorities erected small walls with a view to stopping the fall of other boulders from here and nearby.

Recommendation 24.—The height of these preventive walls with advantage could be increased. Further underpinning of the overhanging blocks of dolomite by the Ramsay Infectious Diseases Hospital should be undertaken.

Recommendation 25.—Much of the eroding part of the spur, which is at the crest of the ridge, could safely be removed across the Upper China Mall which here runs just below the water-shed and on the eastern side of the hill.

Recommendation 26.—The branch drain of drain 2 could with advantage be continued upwards to the Upper China Mall.

3. *St. Loo Gorge to Oak Openings and the area above and below.*

We may now consider the area between St. Loo Gorge and Oak Openings and Limits of sub-section the area above and below, the extent of which may be gathered by a reference to Plates 1 and 3. This sub-section contains notes upon buildings and roads both within and without the grounds of the Philander Smith College. The area described lies to the north-west of that described in the previous sub-section 2.

There are definite signs of subsidence along St. Asaph road from the toll bar at St. Loo Gorge to the Principal's house, Oak Openings, Vegetable gardens. notably a short distance above the Towers, where ten feet of revetment wall along the road has sunk downhill. Vegetable gardens exist above this area and the Tower is very badly cracked. There seems little doubt that the movement occurring here is to be attributed to the water entering the vegetable garden belonging to the College.

Recommendation 27.—I suggest that the continuation of this vegetable garden as such is likely to augment the damage for which it seems directly responsible; and as it is a menace to the safety of the householders beneath, not only the Towers but also the houses lower down the slope, I suggest that the land be sloped and thoroughly drained. Formerly the so-called main fissure of Sher-ki-Danda Hill was traceable only to the St. Loo Gorge and it is shown on Plate 3 as ending there. I do not for a moment think that the movement south-east of the gorge has commenced only in recent years. Oakridge has known to be cracked for some long time, as I shall describe later. However, it seems certain that one of the chief causes of the extension of the fissuring beyond St. Loo Gorge to the end of the spur beyond the class room of the Philander Smith College is the easy access which has been given to water in the vicinity of the St. Loo Gorge, particularly the vegetable garden in the College compound to which I have referred. If water gains access and is permitted to initiate its destructive work here, it is only reasonable to expect that the work of damage will be continued progressively further to the south-east. The vegetable garden, I understand, is cultivated partly for the College authorities and partly for the occupants of the tenement house referred to below.

Recommendation 28.—In the College compound above the vegetable garden to which I have referred at some length, there is a tenement Tenement house. house that was formerly clerks' quarters, but is now occupied by College servants. It is for consideration whether or not it should be condemned. Part has already been demolished, but the debris have not been cleared away. The paths in this area are likewise undrained.

Recommendation 29.—There is a disused tennis court between the vegetable Disused tennis court. garden and Oakridge Cottage, which badly needs attention to its drainage. The Cottage itself seems quite stable.

Oakridge is within the College grounds and lies to the south-east of Oakridge Cottage. It has been cracked for a long time, the main crack running longitudinally through the house and an outhouse to the south-east in a south-easterly direction. That part of the outhouse nearest St. Asaph road seems to have subsided downhill at least six inches and the hump in the middle of the roof of the outhouse is very noticeable. Oakridge itself also seems to have subsided towards St. Asaph road.

Recommendation 30.—Careful attention should be given to the drainage of the outhouse and compound of Oakridge and the water led to a road and thence by a *pucca* drain to the Upper China Mall.

Recommendation 31.—The drainage of the Towers, and its outhouses especially, should be attended to: also that of the path leading to the Towers from the Upper China Mall.

The Towers.

Signs of movement can also be observed in the revetment walls of the road below Oakridge at the entrance to the Philander Smith College. The outhouses of Braemar beneath seem to be badly cracked.

Braemar.

Recommendation 32.—The disused tennis court below Braemar could be drained and attention given to the revetment wall there that has partly fallen down.

St. Loo house has been repaired and is well drained, but the drainage is led to the outhouses which are undrained. These outhouses are still unleased by the Public Works Department authorities.

St. Loo.

Recommendation 33.—All drainage of St. Loo house and outhouses should be led to the nearest branch of drain 16 in St. Loo Gorge. It is for consideration whether or not the small vegetable garden of St. Loo should be sloped off. I consider that this would add to the stability of this part of the Ravenswood spur.

4. Alma Lodge to St. Loo Gorge and the area above and below.

We may now consider that part of Sher-ka-Danda Hill between Alma Lodge and the St. Loo Gorge, which area includes the site of old Government House. As noted on page 16, there are several pairs of pillars erected on either side of the main fissure of Sher-ka-Danda, which runs from the St. Loo Gorge a short distance below the crest of the hill to Snow View and thence across the Gorge through Alma House finally to die out along the Tonnochy road. The latter part of its course will be considered in sub-section 5. At present it is convenient to trace it north-westwards from St. Loo Gorge.

Limits of sub-section.

Recommendation 34.—A *pucca* drain should certainly be constructed up the dip in the slope from the pillar box at St. Loo Toll Bar to the flats on which stand the old Staff Quarters, now the Public Works Department Inspection Bungalow. This seems to be the line of direction of the main fissure and as the dip is used as a short cut by coolies, erosion of the hillside is at present being given every assistance. It is essential that storm water should be removed as quickly as possible from this main fissure area.

St. Loo Gorge.

Recommendation 35.—The further removal of shale from near the pillar box for road-surfacing operations should be prohibited. So much has already been removed that a depression has been formed which, if care is not taken, will serve as an ideal sink hole for the infiltration of water.

Recommendation 36.—Part of the drain along the road from the St. Loo Gorge to the Public Works Department outoffices (see plate 1) needs repairing. Other parts of this road have no drains. As it crosses the main fissure early attention should be given to its drainage.

Recommendation 37.—The roadside drains along Snow View road from St. Cloud to the entrance to the Inspection Bungalow need attention. I visited this area after heavy rain and it was evident that the present drains serve but little purpose. Most of the rain water goes down the hillside.

Snow View road.

As has been noted on page 13, the present Inspection Bungalow is the old Inspection Bungalow. Staff Quarters which were not dismantled at the time when old Government House was demolished (1899). I have referred to the crack behind the main fissure which seemed to pass through the Staff Quarters. The engineers concerned have every cause to congratulate themselves on the fact that the demolition of old Government House seems to have had a very beneficial effect upon the stability of this critical part of Sher-ka-Danda Hill.

Recommendation 38.—I still recommend a very close watch on the movements between the pairs of pillars along the old main fissure. Though the movement here has gradually become less, as noted on page 16, the constancy of movement shows that equilibrium has not yet been reached. Any large movement here should not be allowed to go by unnoticed.

The site of Durga Sah's old tennis court is below the Snow View road mentioned above. A footpath from this road downhill to the tennis court, just at the entrance to the Inspection Bungalow, practically acts as a drain.

Recommendation 39.—This should be made *pucca* down to and across the old tennis court to the nearest branch of drain 18.

The platform next to pillar J on the tennis court appears to have moved away from J downhill, showing that subsidence has taken place here. However I think that it is mainly cap soil movement and anxiety need not be felt provided the drainage recommended above is adopted.

The revetment wall of the Upper China Mall from St. Loo under the Inspection Bungalow is very badly cracked and the roadside drain below Inspection Bungalow has sunk a foot or more. Tell-tales dated, June 13, 1937, have been fractured.

Recommendation 40.—The removal of shales from above the wall for road-surfacing operations should be entirely prohibited. There is little doubt that this practice has aided the entrance of water and enabled it to bulge the soil cap here.

Recommendation 41.—There is no downhill drain along the Upper China Mall between drain 16 at St. Loo Gorge and a branch of drain 18 and the subsided portion referred to above lies within this portion. It would seem advisable to construct a *pucca* drain here down the lower slopes of old Government House grounds.

Recommendation 42.—The small cultivated patch by the disused lower tennis courts in the grounds of old Government House should be drained and cultivation prohibited here.

Recommendation 43.—The roads in the lower grounds of old Government House badly need their drainage attended to. These roads are now public thoroughfares, and as little or no attention has been given to them or to their drainage, they are in a bad state of disrepair. It is just as essential now as in the days when the question of the demolition of old Government House was being discussed, that the drainage of this part of Sher-ka-Danda, the upper Edgehill spur, should be in an efficient state.

Recommendation 44.—A tell-tale, dated 1936 in the revetment wall of the Middle China Mall by drain 18 has been fractured. The hillside above is rather denuded and also there is a coolie path giving free access to water. The steeper part of the slope below the Middle China Mall is apparently safe. I think the movement is purely local and attention needs to be directed to the prevention of erosion here.

Recommendation 45.—Attention should be directed to the drainage of the Tara Hall, Brackenbury Hall and Tara Cottage, disused tennis court below Tara Hall and Brackenbury Hall, and, also, to the drainage of Tara Hall itself and its paths. The drainage of the paths to Tara Cottage, its compound, and in front of its out-houses needs attention.

Recommendation 46.—The roadside drains along the Snow View road between the entrance to Snow View and the entrance to Alma Lodge pass over the main fissure and should be repaired so that all water is quickly removed from this dangerous area.

Recommendation 47.—The vegetable garden on the spur below Snow View should be condemned and the ground sloped off and thoroughly drained. Vegetable gardens should not be allowed on the upper part of Sher-ka-Danda Hill. Little notice seems to be taken of recommendations to this effect, as witness the case of the vegetable garden at St. Cloud, the sloping off of which was recommended by the 1927 Committee. Plate 5 is a section down the slopes of Sher-ka-Danda Hill below Snow View and through the tennis court of Charlton Lodge. The deleterious effect of water entering the upper part of this Charlton Lodge spur by way of Snow View vegetable garden can easily be understood.

It may be noted here that the trap sheet at Alma Lodge, to which reference is made in an extract from Middlemiss' report on page 7 of this report, cannot be considered as in any way increasing the stability of the hillside here.

Recommendation 48.—The rather prominent bulge in the revetment wall along the Charlton Lodge road just above Mr. Balbir Singh's residence should be carefully watched.

Recommendation 49.—The roadside drain along Middle China Mall between Maldon road and drain 20 needs attention.

Recommendation 50.—The old refuse pit near Maldon Cottage at the top of the slip of 1860 should be filled in.

I agree with the engineers concerned that the trouble recently experienced in the high revetment walls below Charlton Lodge is to be ascribed to faulty construction and poor drainage. The present work seems satisfactory and there should not be any further trouble experienced here for some time at least. However, as will be seen from the section forming Plate 5, the slopes here are very steep and in places are over 1 in 1. The spur unfortunately is very heavily built upon and one cannot give any recommendations for its safety other than constant care of the drainage. It seems essential, however, that the recommendation 47 regarding the vegetable garden at Snow View should be given effect to in the interests of the safety of the houses situated lower down this very steep spur.

5. *Tonnochy House to Alma House and the area above and below.*

The main fissure of Sher-ka-Danda Hill crosses the gap between Alma Lodge and Alma House (*see* Plate 1 and Plate 3) and continues towards Tonnochy House. Signs of movement are shown by cracks in Alma House and the downwards sloping of its plinth.

Recommendation 51.—The drain behind Alma House should be cleaned and repaired and the water led to the nearest branch of drain 23. At present the water is allowed to discharge on to the spur unchecked.

Recommendation 52.—That part of the vegetable garden in front of the outhouses of Alma House should be drained as at present it is the intake of a lot of water which must find its way to the main fissure. If this part of the

vegetable garden is condemned, there would still be available for cultivation that part of the garden towards the Municipal Board Ranger's house on the eastern side of the spur.

Recommendation 53.—The roadside drains along Tonnochy road from Alma House to the entrance to Fairlight Hall should be repaired and the road sloped to the drains. At present all rain water goes down the hill-slopes and the drainage system seems useless. A large quantity of spring water discharges through a hole in the slates just above the road in this portion and this certainly should be led away as soon as possible. There is also evidence of much erosion by surface water above a branch of drain 23 near Alma House. This branch drain should be continued upwards above Tonnochy road.

VI.—General discussion on Sher-ka-Danda Hill.

It might be thought from the very numerous recommendations that I have made in section V that I have given too much time to minor details of drainage and not enough to the broader issues affecting stability of Sher-ka-Danda Hill as a whole. I hope to be able to dispel that erroneous conclusion; but, meanwhile, I should like again to point out that it is absolutely essential that the drainage of Sher-ka-Danda should be kept in a high state of efficiency. Apart from that of the College grounds, which is definitely bad, one might state that in general the drainage of Sher-ka-Danda Hill is in a fairly satisfactory state. Certain areas need considerable attention, and I trust that the recommendations that I have made will be followed more or less completely. In this connexion, however, I would add that it is certainly not right that the Municipal Board and/or the Public Works Department authorities should take every possible care of the public drainage, whilst house owners and lessees neglect their equally important work of maintaining the drainage of their buildings and grounds in an efficient state. I believe that the Municipal Board already has powers to enforce the efficient upkeep of the drainage of private houses; but in how many cases has this been enforced? As a general rule, when a house is not let for the season, its drainage is absolutely uncared for. But the owner of that house has a certain responsibility to the owners and occupants of other houses above or beneath his; and they rightly have cause for complaint if the drainage of a house above or beneath theirs is allowed by neglect to become so parlous that a considerable quantity of water is permitted to enter the soil cap and possibly penetrate to the solid rocks beneath, thus affecting the stability of the spur on which the offending house-owner's house is built.

As I have stated upon page 19, I consider that the College authorities themselves are fundamentally to blame for the past and present precarious condition of many of their buildings through neglect of drainage. It is easy to be wise after the event; but surely with many miles of lined drains redounding to the credit of the Public Works Department authorities and the Municipal Board and as an example before them, the College authorities should have realized that it would have been wiser to spend a little money upon drainage, than to spend much more later on repairs to buildings.

Another point upon which little forethought seems to have been spent is the construction of building of heavy buildings on the top slopes of a steep hill earthquake-proof buildings desirable that has been known to be unstable for over 70 years and in a region known to be subject to earthquake shocks. In his classic description of the seismic phenomena of British India [*Mem. Geol. Surv. India XXXV, part 3, p. 158, (1904)*], de Montessus de Ballore states that the "country from Simla to Naini Tal, Sirmur, Kumaun, and Nepal is unstable, but the earthquakes have never had serious results; perhaps only on account of the absence of large towns".

Holland stated on page 47 of his report :

"Although of course the destructive action of earthquakes in Naini Tal can no more be foreseen or guarded against than in other hill stations, or in the plains, it goes without saying that the liability to destructive effects is greater where the slopes are already near the limit of normal stability. The danger arising from earthquakes is, moreover, increased by the liability to shocks progressing north-east and south-west at right angles to the strike of the slates in Sher-ka-Danda, and consequently to the great fissure which is known to run through the hill on which Government House stands; at right angles, that is, to the line of folding of the Himalayan range itself, which is marked in this particular area by the N. W.—S. E. synclinal axis parallel to the greatest length of the lake and of the lake-fault, which, as I have already shown (paragraph 66), is geologically very young, younger than the deposition of the Nahan sandstones, connected with the folding of the Himalayas, and therefore possibly still a line of movement."

With modern developments in the construction of earthquake-proof structures, as outlined from time to time in the reports by various officers of the Geological Survey of India, it is possible largely to guard against the destructive effect of earthquakes. It is obvious that buildings erected in Naini Tal should be light in structure and, if possible, built on earthquake-proof lines. The very heavy earthquake-proof buildings are obviously unsuitable for the station with its own peculiar geological structure.

I have given extensive extracts from Holland's report describing the geology General condition of of Naini Tal and the stability of its hill slopes. The chief Sher-ka-Danda Hill. point at issue now is whether or not the subsidence and fissuring recorded at length in section V is superficial and so of no great importance. Holland was of the opinion that the fissuring was not superficial, but it was possibly not more than 50 feet below the foundations of old Government House. He considered that the wedge of strata that was subsiding would not slide off like an ordinary landslip as long as it is kept dry. He concluded that as long as Edgehill and Ravenswood stood, there was no possibility of anything approaching a landslip. Oldham uttered a warning against a false feeling of security based on these remarks and said that landslips do occasionally start from the crest of a hill such as Sher-ka-Danda. He considered that the symptoms the hill showed were those which are recognized as premonitory of a free landslip.

It would appear from the tables of movement of pillars given on pages 16 to 18 (inclusive) that the old main fissure of Sher-ka-Danda has gradually been healing up under the influence of the curative that have been adopted in past years by the engineers concerned, all mainly directed to the prevention of access of water to the main fissure and the cleavage and stratification planes of the shales and slates constituting the hill. However, as noted upon pages 17 and 27, in spite of all the curative measures, there is still definite movement, though admittedly small in amount, along the old main fissure; and it was to prevent any deterioration of the general improvement that I have given extensive recommendations for the still further improvement of drainage.

On the other hand, whilst we may state that the condition of the old fracture line has improved, in so far as decreased movement can be considered improvement, the condition of that part of Sher-ka-Danda Hill to the south-east of the St. Loo Gorge has definitely worsened. The fissuring that has recently been aggravated there is undoubtedly of the same type as that along the main fissure of Sher-ka-Danda through the grounds of the old Government House; also it is connected in origin with the main fissure. It is not just mere surface cap soil movement, but actual fissuring of the underlying rocks. Its direction is mainly parallel to the strike of the rocks and there are at least three main fissures, more or less

parallel in direction and trending south-east or S. S. E. One cannot of course give the depth of these fissures, but I should imagine that they are somewhat of the same depth, or slightly less, than that assumed by Holland for the old main fissure of Sher-ka-Danda Hill, i.e., 50 feet.

I agree with Oldham rather than with Holland and I have but little doubt that if the present unsatisfactory state of the drainage in the College grounds, is allowed to continue, in the course of time a major catastrophe will occur. One might refer here to the remarks of Oldham, quoted on page 9 of this report, in which attention is directed to the very rapid development of a serious state of affairs along the old main fissure line on Sher-ka-Danda in the five years after 1889. He noted that if he had had any suspicion that this rapid development would take place, he would have used very different words describing the conditions when his opinion was asked in 1889.

It might be many years before a free landslip did occur, but from year to year, as the fissures in the College grounds widened and more and more water was permitted to lubricate the sliding planes (stratification planes) of the rocks, the process of destruction would be hastened. Probably not all the sliding mass from the gorge at St. Loo to the Sports Field would go in one fell swoop; one would not expect this, but a number of minor slips, which would prepare the way for the final catastrophic landslip which would destroy most of the houses on the lower slopes of Naini Tal above the lake.

However, what has already been accomplished for the Edgehill spur under old Government House can also be accomplished for the spurs on which the Philander Smith College buildings are built. At present, luckily enough, there is no sign of movement at the toe of the steep bulge above the tennis court of Jakhwal Sadan, as shown in the section forming plate 5 of this report. Indeed the cliff wall of the tennis court here is not revetted, and yet it shows no sign of movement. However much satisfaction may be gained from this fact, let me add that if unchecked movement is allowed to take place at the top of the spur by Laidlaw Hall and the other buildings of the College, then in the course of time the repercussions of that movement must be found in the supporting slopes below. It is of course somewhat fortunate that the slates and shales here have generally a dip towards the north-west, whereas the slope of the hillside is to the south-west. So the apparent dip of the strata in the direction of the hill-slope is small and the sliding movement of the upper strata will be mainly to the north-west and not directly down the hill. However this must be considered with the fact that on the south-eastern sides of the transverse valleys and depressions in the general slope of Sher-ka-Danda here, the shales and slates are generally free to slip in the direction of their dip.

Matters in the area under discussion are somewhat complicated by the existence of the cross-fault to which I have referred to on page 21. This has offset the two outcrops of dolomite shown on Holland's map and must still be a plane of weakness. It is perhaps significant that most of the fissuring in the College grounds (near Laidlaw Hall) has occurred near this cross-fault.

To my mind, it is only a matter of time before slips occur in this region south-east of the St. Loo Gorge if no attempts are made to rectify the existing state of the drainage. One cannot give any idea of the length of time it would take under free conditions for this to happen; but, in any case, it is essential that the problem of drainage should be taken in hand immediately. Unfortunately it will probably not be possible to tackle the problem seriously before the present rains have finished. If these are heavy and prolonged, as seems possible from the present vigorous state of the monsoon, then I fully anticipate that further serious fissuring and subsidence will take place in the College grounds during the

present rains. Such being the case, I would again direct attention to my recommendation 13, regarding the present classroom, given on page 23. It would be very wise to condemn this building immediately.

Recommendation 54.—In my description of that part of Sher-ka-Danda Hill from Oak Openings to the Ramsay Isolation Hospital (see page 21), I have referred to the fact that drain 13 at present limits to the south-east that part of the hill designated as dangerous. On page 4, I have stated that the Public Works Department authorities have suggested the inclusion within the dangerous area of that part of Sher-ka-Danda Hill outlined in blue on plate 3 of this report, which would serve to make the so-called dangerous area much larger than before. I am in complete agreement with this proposal and suggest that steps should be taken immediately to enforce this. The fissuring and subsidence that have already occurred in the upper parts of Sher-ka-Danda Hill, in the grounds of the Philander Smith College in particular, are enough to cause grave anxiety about the safety, not only of that upper part, but also of the lower slopes of the hill beneath the fissured area. Though one might gather from the dips of the shales and slates, as shown in Holland's map, being directed to the north-west and so not in the same direction as the slopes of the hill, which are to the south-west, enough has been stated in the foregoing discussion to make it clear that there is a real danger in this extra area of slipping. Such being the case, in the interests of safety of the settlement, I most strongly support this proposal to enlarge the dangerous area of Sher-ka-Danda Hill as shown on plate 3.

Recommendation 55.—To my mind, the slopes of Sher-ka-Danda Hill are already overbuilt upon and I recommend that no further building be allowed except in very exceptional circumstances; and then only in sites concerning which no anxiety may reasonably be expected. When it is proposed to demolish existing structures and rebuild upon the same site, this should be allowed only when the new structure is to be lighter than that demolished. It is very desirable that new buildings should be built upon light earthquake-proof lines.

Recommendation 56.—Every care should be given to the afforestation of recently denuded areas on Sher-ka-Danda Hill.

I feel it incumbent upon me to refer to Middlemiss' remarks (see page 8 of this report) about the possible site of the next landslip in Naini Tal, but which he did not specify. Although it is now 49 years since his paper was published, there so far has luckily been no serious landslip on Sher-ka-Danda Hill, credit for which must be given to the engineers concerned and the remedial measures that they have adopted. It cannot be doubted that had Nature been allowed to wreck its will unchecked upon Sher-ka-Danda, since the time of Middlemiss' report (1890), there would be a very different configuration of the slopes of that hill from that which it possesses at present; and, also, probably the landslip foretold by Middlemiss would have been chronicled. Holland does not seem to have attempted to locate the site to which Middlemiss referred, though his last investigation of the hillsides of Naini Tal took place only 16 years after the publication of Middlemiss' report. A reference to his geological map shows that his cross-sections through Sher-ka-Danda Hill only cover the area between Fairlight Hall and Braemar; but he has noted (see page 10 of this report) that in most of these cross-sections, the steepest slope is near the base, bearing out Oldham's remarks (see page 5) on the origin of these bulges.

Holland's geological map must show the site referred to by Middlemiss as all slopes over 37° are shown by dark shading. In that part of Sher-ka-Danda Hill

Extract copy of Municipal Department G.O. No. U/561/XI dated December 18, 1942,
Deputy Commissioner, In-charge Kumaon Division.

Subject:-- Dr. Coulson's report on the safety of certain areas in Naini Tal.

* * * * *

I am also to request you to impress on the Board the necessity of restricting the use of motor cars on the Mall beyond Talli Tal as much as possible. At present with the exception of a limited number of high officers none else is allowed to take a motor car beyond the Talli Tal lake bridge without the express permission of the Chairman, Municipal Board. The Governor considers that the latter should give this permission even more sparingly than he has done in the past. For instance permission should not be given for weddings; it should only be given in case of a serious sickness for an ambulance etc. This should be impressed upon the Chairman.

MUNICIPAL OFFICE,
Naini Tal.

No.....

Dated.....1943.

Copy forwarded to.....
reference to his letter dated..... It is regretted that in
of the above orders no permit to take a car beyond the Talli Tal lake bridge
be granted except in the case of a serious sickness.

SECRETARY,
Municipal Board.

to the south-east of his last cross section (no. 11), most of the dark-shaded areas shown by Holland, with the exception of that at Melville Hall, are not at the base but midway up the hill slopes. Thus Middlemiss' site would appear of necessity to be within the area to the north-west of Melville Hall.

At the present moment, as far as can be seen, there are no indications of the near likelihood of a slip in this region. One must conclude, therefore, that wherever the particular site that Middlemiss had in mind may be, the conditions have been very materially altered since his visit. Personally I consider the whole hillside is in a delicate state of equilibrium and is more or less equally dangerous. Accordingly I would hesitate to place the site of the next landslide on Sher-ka-Danda Hill on any particular spur, always provided that the drainage is kept uniformly efficient and that attention is paid urgently to those areas where I have indicated the drainage conditions are at present unsatisfactory.

VII.—Committees on hill-slopes of Naini Tal.

It is for consideration whether or not the hill-slopes of Naini Tal should be Desirability of a inspected regularly and reported upon by Committees far less Committee every five years. infrequently than is at present the case. It will be recalled that the Berthoud Committee of 1907 recommended that the hillsides of Naini Tal should be examined by a special Committee at intervals of not more than three years; but in spite of this recommendation, the next Committee, of which I was a member, was not convened until 1927, 20 years afterwards. The following Committee, that of 1937, was convened at an interval of ten years but no geologist was a member of that 1937 Committee. With most of the hillsides of Naini Tal in a very critical state of stability, and with Nature ever modifying the conditions of equilibrium of the constituent rocks in spite of Man's best efforts to avert this, it seems to me eminently desirable that the hillsides of Naini Tal should be reported upon by a Committee, including a geologist, at no very distant date.

Recommendation 57.—I have given Sher-ka-Danda Hill a thorough examination this year (1939), especially those areas in which trouble has lately been experienced; but I think that in 1942, five years after the examination by the last Committee (1937), a new Committee, including a geologist, should be convened to report on the general conditions of stability of the hillsides of Naini Tal, more particularly with a view to seeing to what extent the fissuring on Sher-ka-Danda Hill has been arrested by the adoption of the remedial measures proposed in this report, and to what extent Gangipur spur, on which is situated the pipe-line of the Naini Tal Municipal Board's hydro-electric scheme, has healed by the adoption of the remedial measures outlined in my report of July, 1939. Thereafter, Committees, always including a geologist, might perhaps be regularly constituted at five year intervals, unless any major catastrophe intervenes, to report upon the hillsides of Naini Tal in general and of any particular site concerning which anxiety is being felt by the engineers concerned.

VIII.—The use of motor vehicles in Naini Tal.

Having the interests of the safety of Naini Tal at heart, and in view of my Unsatisfactory state acquaintance with the hill station and its own peculiar of affairs. geological conditions for some time, I feel called upon to draw the attention of the Local Government and the Municipal Board to the present unsatisfactory state of affairs regarding the use of motor vehicles within the limits of the Municipality. At present, I understand that the Chairman of the Municipal Board, or the Secretary of that Board, is the authority empowered to

grant permits for the use of cars within Naini Tal. Normally permits are granted for the use of cars upon arrival and departure from Talli Tal up to the Secretariat, and only then under special circumstances in which the rank and position of the individual applying for permission is naturally considered.

One cannot state that the safety of any part of Naini Tal is directly impaired by the use of motor cars *along the Mall road* as far as the Secretariat. Once cars are garaged near the Secretariat, however, it is difficult to prevent their use on roads which are certainly not safe for the cars themselves, apart from the fact that their use is liable to affect the stability of the hillsides on which those roads are aligned. I am aware that cars were driven beyond the Secretariat during the period of my visit to Naini Tal.

In my draft report, I had written that I most strongly recommend that cars should not be allowed along the East Laggan road in the interests of safety of the hill-slopes there if for no other reason. During the interval between the drafting and typing of my report, I have received information from Mr. M. B. Hatfield, Executive Engineer, Public Works Department, Naini Tal, regarding the recent serious subsidence of large blocks of dolomite near the East Laggan road and the fall of other boulders across this road. It has, accordingly, rightly been closed to all traffic. I had already anticipated that trouble would occur through the use of cars on this dangerous road; but am not in a position to state what part of the present trouble, if any, arises from the cause stated. I deal more fully with the recent developments at this part of Ayarpatta in section X of this report.

Another road upon which I anticipate trouble will occur through the use, in this case, of heavy motor lorries, is the Depot road. The subsidence in this road has certainly not worsened during the past 12 years, but the hill-slopes along it are still in rather a critical state of equilibrium. The 1937 Committee recommended that if no further subsidence was observed in this road, a diversion should be made by cutting into the hillside. I have not considered thoroughly on the site the merits of this proposed diversion, but on *a priori* grounds, I would be against it. This road is, of course, within the Cantonment area and is vital to their lines of communication. It is a dangerous road, and especially unsafe in parts for the use of heavy vehicular transport. Though I have driven cars over more dangerous roads in Tribal Territory, Kashmir, and other places, I would hate to drive a heavy motor lorry over certain parts of the Depot road, knowing its condition of geological instability. Personally I feel that this Depot road should be closed to motor transport, or at least to heavy motor transport.

It is common knowledge that cars are used for shopping purposes in Naini Tal. I have seen a car drive down to the Naini Tal shopping area and a servant get out, make his purchases, and then drive off in the car. One has only to be a pedestrian using the roads of Naini Tal and to be passed by a car to realize the discomfort of being smothered in dust, or being forced into the road side drains to allow that car to pass, and to gain some idea of the grave danger to children and riders through the use of cars.

Recommendation 58.—Naini Tal is a hill station in which abundant transport is available in the form of dandies, rickshaws and horses. There seems to be no necessity for the use of cars within the Municipality; and in view of the grave dangers arising from their indiscriminate use, as has latterly been the case, I suggest for the consideration of the Local Government and of the Municipal Board that the use of cars beyond Talli Tal should be prohibited without exception.

IX.—Removal of blocks of dolomite from above Chitrakut, Brinsop road.

At the request of Mr. M. B. Hatfield, Executive Engineer, and in company with him and the Assistant Engineer, Public Works Department, Naini Tal, I visited the outcrop of dolomite near Chitrakut along the Brinsop road.

To my mind, there is no doubt that the dolomitic masses above the Brinsop road here constitute a very real danger to those using that road. The dolomite is very shattered and fractured and has the appearance of having been struck by lightning. This, however, is apparently not the case and the fracturing seems to have been due to the natural processes of weathering. Many large blocks of dolomite, some weighing several tons, are due to fall across the road within a very short time. The Public Works Department authorities have realized this and Mr. Hatfield has had a notice put up warning users of Brinsop road to beware of falling boulders and has erected a safety catch wall on the hillside of the road, with the idea of preventing falling masses of dolomite from crossing it.

Alternative courses of action.

There are three courses of action available—

(1) The present catch wall should be increased in size. I do not think this will be efficacious as the wall, by reason of the alignment of the road, is perforce situated too close to the foot of the overhanging masses to have much practical utility.

(2) The catch wall could be re-erected upon the site of the present road and a diversion made for the road. This is likely to be very expensive as the slopes are very steep and a girder bridge would have to be used. In addition, though the catch wall would have a better chance of preventing falling masses of dolomite from crossing the road, it is not absolutely certain that it will invariably do so. On the contrary, I think it is quite probable that some would break the wall down, or would be shattered on impact and pieces would fly over the catch wall.

(3) The third course of action is to remove the threatening masses of dolomite, as has been done in the case of dolomitic boulders near Kailash.

Recommendation 59.—I am in agreement with the engineers concerned that this third course of action should be followed as soon as possible. We attempted to climb the twin peaks of dolomitic rocks, but found it impossible to do so on account of the cavernous chasms, due to solution along major jointplanes and the removal of the material so dissolved, with which the dolomite abounds. However, we decided that the best way of removing the disjointed masses in question would be by a charge set on the western side. It is possible that the nearest building of Chitrakut would suffer damage from flying pieces of dolomite when the charge is fired; and so it would be essential to cover the roof with planks of wood. However, points of this nature may safely be left to the engineers concerned. I conclude by advocating once more the early removal of the threatening blocks of dolomite.

In a letter dated July 29, 1939, Mr. Hatfield informed me that a crack subsidence near has developed below Brinsop on Brinsop road. The house Brinsop is not endangered as the movement is above the south approach. However, he was taking the precautionary measure of closing the road until the underpinning of the lower blocks was completed.

Until my visit of inspection referred to previously, I personally had no idea that the chasms dissolved in the dolomite of Naini Tal attained the dimensions they possess, e.g., near Chitrakut. Realizing this, however, it is small wonder that subsidence occasionally takes place in dolomitic areas, where houses have been built over cracks, the existence of which was not known; or, alternatively, that there are other signs of movement. Brinsop is very near the Chitrakut boulders we have been discussing; but without a personal visit to the site in question, one cannot advise remedial measures, more so as I have no doubt those already taken by Mr. Hatfield will meet the case.

X.—Area near Killarney.

On page 34, I have referred to recent information received from Mr. M. B. Hatfield since the drafting of this report, concerning serious subsidence and cracking that is at present taking place between the East Laggan road and the South Mall, below Killarney. Whilst I was in Naini Tal, I did not visit this area with the idea of advising upon it, as then no problems had arisen. At the present moment, also, I hesitate to advise on the stability of this hillside, except in general terms. However, the following information and general comments may be of some little value.

According to Mr. Hatfield, in a letter dated July 29, 1939, the spur below Killarney has developed cracks and boulders have moved. One in particular, weighing some 60 tons, has subsided two feet and at its top is two feet away from the hillside.

"It is hanging on by its teeth, and I do not understand why it did not go down altogether. I enclose a rough sketch showing what has happened. I send you this information as I know that you are interested in what happens to these hillsides."

Mr. Hatfield enclosed a copy of his letter to the Deputy Commissioner in-charge, Naini Tal, in which he stated :

"Cracks have appeared in the spur of the hill below Killarney between East Laggan road and the South Mall, and that several boulders have slipped from their original positions. As I consider that there is a possibility of a slip, I have closed the South Mall and have erected barriers as follows :

- (1) Near the Temple by the Flats.
- (2) Near Ousley Road.
- (3) One on the Malli Tal side of Pakhan Devi.

2. The barrier at Ousley road is intended to stop people who wish to go through to Malli Tal, but people who wish to go to Pakhan Devi for worship will be able to pass the barrier but will be stopped from going from Pakhan Devi to Malli Tal by the barrier just beyond Pakhan Devi. No remedial measures are possible at present, and, as such, the South Mall will remain closed until after the rains when it will be seen what measures can be taken.

3. I will be glad if you will inform the official receiver of M. Abdul Qayum Khan's estate that he should warn the residents of Killarney that until further notice they reside in Killarney at their own risk.

4. I am writing to the Military Secretary to His Excellency the Governor, and am asking him to inform His Excellency that I do not consider it advisable for him to take his car up the East Laggan road."

The sketch forwarded by Mr. Hatfield showed three main new cracks between East Laggan road and the South Mall. The uppermost of these was 30 feet long and 3 to 6 inches wide ; this is along the continuation of an old crack line. The middle crack was 26 feet in length and 4 to 6 inches wide ; near it was a slipped mass of dolomite, 20 feet by 14 feet. The lowest crack was somewhat horse shoe-shaped, over 26 feet in length and four to 10 inches in width.

In a further letter, Mr. Hatfield stated that the large boulder of 60 tons fell at 1.25 a.m. on July 31. The East Laggan road was breached and the Middle Ayarpatta Mall partly so. Numerous cracks have appeared above and around up as far as Killarney. Mr. Hatfield enclosed a copy of his letter of July 30, 1939, to the Deputy Commissioner in-charge, Kumaun Division, in which he stated :

"I consider the situation as very serious. Since my report to you dated July 29, 1939, cracks have appeared in the East Laggan road, Middle Ayarpatta

subsidence became aggravated between 1890 and 1892. Falls of boulders from below occurred in July, 1893, and a large crack was developed about 120 feet from the huge boulder of Craig Ellachie. On July 30, 1893, a large portion of the hill, extending nearly up to the road under East Laggan, fell into the lake. On October 19, of the same year, after about 30 inches of rain in three days, another slip further to the north-west occurred, the fall of rocks and trees into the lake raising a wave which swamped the Mall on the opposite side.

"Between the sites of these two slips there was built in 1888-89, on the road beside the lake, a buttress of solid masonry 100 feet high, and above this point the rocks have remained undisturbed. The support rendered by this revetment may have been just sufficient to prevent a coalescence of the two slips; but if my interpretation of the geological structure is correct, that portion of the slope is now in a condition of decidedly unstable equilibrium, as such a slender piece of masonry would be quite insufficient when, by further depression, the weight of the rocks in the steep cliff comes to bear on it."

Examining the cause of the slip, Holland notes that the dolomitic sandstone dips at 47° to N. 10° E., at right angles to the shore of the lake at this point. The sandstone has been decomposed in the outer portions

"and is surrounded by a thick crust of rusty, crumbling sand, from which the carbonates of lime and magnesia have been removed and the iron compounds oxidized and hydrated by the atmospheric waters sinking through the soil and percolating through the rocks below. Action of this kind has taken place along all the joint-planes, but naturally has received greatest facility for decomposition along the more perfectly developed bedding-planes, the residue of crumbling sand acting as a lubricant between adjacent faces of compact rock. Any slope, therefore, in this formation having a greater inclination to the horizontal than the dip of the sandstone, will be liable to slips, until the surface slope and the bedding-planes coincide. In the case of East Laggan the dip of the sandstone is about 47° , and the outer slope of the cliff 52° . There is, therefore, as shown in the section (no. 16, Plate VII), a wedge of rock ready at any time to slide off towards the lake, and whenever settlement occurs cracks parallel to the strike of the sandstone will appear at the surface. I should have no hesitation in condemning as unsafe the whole of the ground between the broken lines in the section. Any house built within this area will never stand long without being cracked by differential settlement, and will be liable at any time to be carried away altogether by a sudden landslide. The circulation of rain-water along the bedding and joint-planes of this sandstone will continually make it unsafe, and an earthquake (not unfrequent in this area), or heavy rain, may at any time carry the whole of the ground into the lake. It may be mentioned that East Laggan is not far removed from the place marked by Mr. Middlemiss as the point where three faults cross, and in their vicinity the rocks have been crushed, and so rendered less stable; but this fact, though complicating possibly the nature of the movement, does not affect the conclusions stated above concerning the instability of the ground under East Laggan."

Holland referred to the earlier opinions of Wildeblood and Oldham regarding this area. In September, 1895, H. S. Wildeblood stated that Holland had exaggerated the extent of the dangerous portions of the slope in his February, 1893, report, and was of the opinion that the roads might be reopened along their old alignments. In October, 1895, R. D. Oldham confirmed Holland's original conclusion that any road carried across the face of the 1893 slips must be of a purely temporary nature, liable to repeated interruptions, and a source of danger in itself, as well as to the hill above and below.

Holland concluded his discussion of the East Laggan area by stating there is no question that sub-aerial water is the principal cause of the mischief. He

considered it would be useless to attempt repairing the two roads broken by the slip.

"If possible, the Upper Mall might be carried along the ground at the back of East Laggan, and even there may be subject to settlement, but of no very serious nature. Whilst a road may be allowable on the lake side of the rock behind East Laggan, any building on that side should most certainly be prohibited.

As long as the steep cliff in front of East Laggan remains, it will always be a source of danger to the road around the lake below; and unless the cost be considered prohibitive, it should even be helped down as soon as possible, a much more satisfactory and less expensive operation than propping it up by masonry on an insecure foundation. The prop now existing between the two slips is highly dangerous, because it is deceptive, and totally inadequate to prevent any settlement in the cliff above."

These views of Holland are extremely important and I shall discuss their implications on what has now occurred almost exactly 46 years after the slips of 1893 that he was discussing. Meanwhile we may turn to such developments later than Holland's report of which we have records.

Berthoud Committee,
1907.

The Berthoud Committee of 1907 stated that—

"As regards East Laggan the Committee have no remarks to make except that they consider that when the road from here to the flats is widened the picturesque rock known as Craig Ellachie should not be touched; the road can be widened on the outside without any difficulty."

This Committee was apparently more concerned with the beauty of the lake than with the safety of the East Laggan area.

Dobbs Committee,
1927.

The Dobbs Committee of 1927, of which I was a member, stated:

"The Committee had the privilege of receiving the expert advice of Dr. E. H. Pascoe, Director, Geological Survey of India. In the opinion of Dr. Pascoe, the rock called Craig Ellachie should be removed. Dr. Pascoe and the Committee consider that the rock, in its present cracked and overhanging condition, constitutes a grave menace to frequenters of the East Laggan road and the Lower Mall. Though the tell-tales inserted by the Public Works Department showed no movements, the fact was due to the cracks in which they were inserted being more or less horizontal in nature. Geological reasons for the removal of the Craig have been given in the past by other geological experts and need not therefore be amplified."

In my "Report on the hillsides of Naini Tal" which was published separately in Lucknow in 1928, I made similar recommendations for the removal of Craig Ellachie and the associated rocks.

The 1937 Committee reported that the above recommendations of the 1927 Committee were carried out and the large rock was removed.

The huge masonry buttress to which Holland has referred as being totally inadequate to prevent settlement in the hill above, is commonly known as the "Folly" of the engineer who constructed it. At the present moment we are dealing mainly with the fall of boulders below Killarney. Their fall may or may not have repercussions upon the stability of that house, but Mr. Hatfield has wisely warned the inhabitants thereof that they do so at their own risk. Trouble will always be experienced in this Killarney, or East Laggan area, until the hill-slopes beneath it have taken up a dip of no greater inclination than the dip of the dolomitic sandstone that dips

towards the lake at 47° under the East Laggan road and the Middle Ayarpatta Mall. The fundamental question that the Public Works Department authorities and the Municipal Board will have to face is, whether or not it is worth while allowing the present unstable conditions to persist? Has the time come for a consideration of the means to be adopted to render this hillside as safe as it is able to become with its own peculiar geological structure? Personally I think that it has. A start was made by the 1927 Committee by the demolition of Craig Ellachie on the recommendations of Sir Edwin Pascoe and myself. The Committee bravely faced the question of the removal of a picturesque landmark, well known to frequenters of Naini Tal for many years past, and decided that beauty was a far less important factor than safety of human life. The Committee of the future is to be faced with a far larger task than the demolition of a large landmark and its satellite rocks. There is the question of the removal of the inadequate buttress and the overhanging cliff it pretends to support. Also the demolition of the houses in this area, Killarney and Killarney Cottage, which are directly threatened, must be considered. It must be realized that the South Mall, East Laggan road, and the Middle Ayarpatta Mall will require expensive realignment were the threatening hillside assisted into the lake. Will it be certain when all this is done that the area will remain quiescent for a length of time comparable with the expense involved? This is a large question which could not be answered without extensive investigations on the spot and the preparation of somewhat extensive estimates.

Recommendation 60.—In any case, I think there is a very definite need for the investigation of the safety of the East Laggan (Killarney) area in the light of the considerations that I have raised above. When the next Committee meets to discuss the safety of Naini Tal hill-slopes, if not before, this matter with all its associated problems should be borne in mind. Meanwhile the engineers concerned may be trusted to take all temporary remedial measures that are necessary.

XI.—Summary.

After a short introduction and history of the present investigation, a full account is given of previous reports dealing with Sher-ka-Danda Hill in Naini Tal, chief among which is Sir Thomas Holland's report, published in 1897, on the geological structure and stability of the hill-slopes of Naini Tal. Tabular statements of the movements of pillars and marks on the hill are then given and then a very full account of geological observations and recommendations made during the present investigation. This is followed by a general discussion on Sher-ka-Danda Hill in which it is stated that apart from the grounds of the Philander Smith College, the drainage of the hill may generally be regarded as being in a fairly satisfactory condition. It is considered that the neglect of the drainage of their grounds by the College authorities and the building of structures too heavy for the sites upon which they are erected are the fundamental causes of the fissuring and cracking that has recently given so much trouble and caused such anxiety about this part of Sher-ka-Danda. The fissuring in the College grounds is undoubtedly of the same type as that along the old main fissure of Sher-ka-Danda and it is also connected in origin with the main fissure. It is not just surface cap soil movement, but actual fissuring of the underlying rocks. Its direction is mainly parallel to the strike of the rocks and there are at least three main fissures, more or less parallel in direction and trending south-east or S. S. E. Matters are somewhat complicated by the cross-fault near the Laidlaw Hall building, but it is perhaps significant that most of the fissuring has occurred near here.

It is considered that it is only a matter of time before slips occur in the region south-east of St. Loo Gorge if no attempts are made to rectify the drainage. It is recommended that the present limits of the so-called dangerous area on Sher-ka-Danda Hill should be extended so as to include most of the hill to the south-east. Some 55 other recommendations of greater or lesser importance have been made, chiefly with the idea of improving the drainage on Sher-ka-Danda Hill.

Among further recommendations dealing with Naini Tal in general and parts other than Sher-ka-Danda Hill, perhaps the most important are the following :

It is considered necessary that the slopes of Naini Tal should be reported upon at intervals of not more than five years by special committees which include geologists. It is suggested that the next Committee should meet in 1942 and should report upon the general conditions of stability of the hillsides of Naini Tal, more particularly with a view to seeing to what extent the fissuring on Sher-ka-Danda Hill has been arrested by the adoption of the remedial measures proposed in this report, and to what extent Gangipur spur, on which is situated the pipe-line of the Naini Tal hydro-electric scheme, has healed by the adoption of the remedial measures outlined in the author's report of July, 1939, on the question of the diversion of this pipe-line.

It is suggested for the consideration of the Local Government and the Municipal Board that the use of cars beyond Talli Tal should be prohibited without exception.

It is stated that there seems to be a definite need for the investigation of the safety of the East Laggan (Killarney) area in the light of certain considerations that have been raised. It is therefore suggested that when the next Committee meets to discuss the safety of the hill-slopes of Naini Tal, if not before, this matter with all its associated problems should be borne in mind.

XII.—Acknowledgments.

I am very grateful to Mr. M. B. Hatfield, Executive Engineer, P. W. D., Naini Tal, the Assistant Engineer, Naini Tal, and their staff for the assistance they rendered me whilst I was investigating those hill-slopes of Naini Tal described in this report. I am particularly indebted to Mr. Hatfield for his courtesy and kindness in forwarding to me in Calcutta, after my visit had terminated, such further information that I required and for keeping me informed of recent developments in the hillsides of Naini Tal.

XIII.—List of plates.

PLATE 1.—Naini Tal Guide Map, published by the Survey of India in 1938. Scale, 6 inches=1 mile.

PLATE 2.—Blue print showing the proposed alterations and additions to Laidlaw Hall of the Philander Smith College. Line Plan. Scale, 10 inches=1 foot.

PLATE 3.—Map (no. 1/1919, M. N. T.) of Naini Tal Station, showing observation pillars and public drains. Also the existing dangerous area and the area which it is proposed to add to the existing dangerous area. Scale, 10 inches=1 mile.

PLATE 4.—Blue print of Longitudinal section of hillside from Laidlaw Hall to the lake, passing through Jakhwal Sadan. Scales, horizontal and vertical, 1 inch=60 feet.

PLATE 5.—Cross-section of hill from Snow View to A. F. I. Club, passing through the tennis court of Charlton Lodge. Scales, horizontal and vertical, 1 inch=60 feet.

A. L. COULSON,

Superintending Geologist,

Geological Survey of India, Calcutta.

August 5, 1939.

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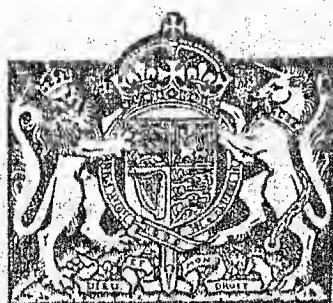
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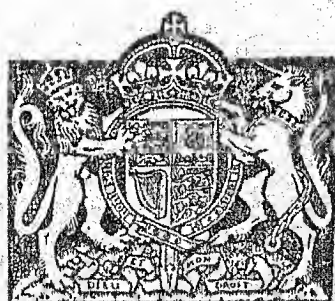
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1937

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REPORT OF THE TECHNICAL COMMITTEE ON THE HILLSIDES AND LAKE AT NAINI TAL, 1937

A TECHNICAL COMMITTEE consisting of :

(1) The Superintending Engineer, II Circle, Provincial Works, United Provinces,

(2) The Superintending Engineer, Public Health Department, United Provinces,

(3) Thakur Madhab Singh Bisht, Assistant Engineer, Naini Tal,

was appointed by G. O. no. 2172C/48C—1936, dated the 3rd February, 1937 "to consider questions relating to hillsides ; the lake being the most important subject for discussion", the terms of reference having already been laid down in G. O. no. 1302C/48C—1936 of 11th August, 1936.

2. The Committee met several times in May and June, 1937 and conducted their investigations under the following heads :

(1) The extent to which the recommendations of the 1927 Committee have been given effect to, and the necessity for making further recommendations.

(2) Movements of hillsides since 1927.

(3) The capacity of the lake to meet the demands of the hydro-electric and water supplies.

The Committee inspected the subsided area on the Depot Road, the old Reserve Police Lines area, Gangipur Spur and Matyali.

3. The extent to which the recommendations of the 1927 Committee have been given effect to :

Item (a) Maintenance of ~~existing~~ protective works

The reference made by the 1927 Committee to "percentage discharge" has been elaborated in item(f) of its report and is dealt with below when discussing that item.

With regard to its references to drains and protective works there are attached to the present report :

(i) A list of drains constructed since 1927 (Appendix A). [A list of drains constructed before 1927 will be found in (Appendix A) to the Report of the 1927 Committee].

(ii) A list of all protective works carried out in the lake area. [Those executed since 1927 are marked with an asterisk (Appendix B)]

In addition to the new construction detailed in Appendix A to this report the following drains, which were of insufficient capacity, have been enlarged since 1927 :

(1) No. 26,

(2) No. 30,

(3) No. 31,

- (4) The branch of drain No. 24 above the Upper Cheena Mall,
- (5) No. 13,
- (6) No. 14,

and, as recommended by the 1927 Committee, drain no. 26 has been re-graded.

In the opinion of the Technical Committee the following additional improvements should be made :

- (a) The ravine from Snowdon to Sleepy Hollow where it joins drain no. 35 should be lined with masonry.
- (b) The unlined portions of drains nos. 3, 4, and 5 on Sher-ka-Danda hill should be lined.

The cost of these works is estimated at about Rs. 5,000.

The drains on Durgapur spur, as recommended by the 1927 Committee, are kept clean and in repair.

The trenches and barriers above the Upper Cheena Mall, designed to trap debris and boulders falling from Cheena, have been improved and extended.

All protective works are properly maintained and have proved of great value. It is hoped that the improvements made to the trenches and barriers will prevent their being passed by falling boulders in future. If this hope is not fulfilled the construction of a second line of defence will have to be considered.

Item (b) Need for further protective works

Proposals (1) (2) and (3)—Have been dealt with by the 1927 Committee in greater detail in item (j) of its report and will be commented on when discussing that item.

Proposals (4) to (8)—These proposals relate to four bits of bad hill side and the Ballia Ravine. The hillsides are the area below the old Reserve Police Lines, Gangipur spur, the hillside carrying the Depot Road, and Kalakhan hill and as will be apparent from plan no. 1 attached, prevention of further movements is dependent on stopping scour in the Ballia ravine.

The only work which has been done so far is the construction of 14 bed bars in the Ballia ravine. The 1927 Committee itself did not recommend the construction of any revetment walls or drains below the old Reserve Police Lines, or the lining of the Ballia ravine beyond the Fairy Hall drain, till the threatened area had fallen ; and it has not fallen yet. Further, as the cost of draining Kalakhan hill would be very high and the dangerous portions are outside the inhabited area, Government were of opinion that there was no justification for the expenditure, at any rate at present. They said, however, that the Gangipur spur should be carefully examined with the object of determining what walls and drains were required.

The present Committee has inspected the Gangipur spur and considers no expenditure on walls and drains justified. Just above where the spur takes off there is a building known as the Rais Hotel, and the Coolie Dhara drain (also called the Police Lines drain), referred to by the 1927 Committee, passes through the area below that building and discharges into the Ballia ravine. The lowest portion

of this drain is unlined. The building is supported by an out crop of dolomite, but the formations exposed lower down the hillsides are soft. The 1927 Committee, it would appear, recommended that the area below the building should be revetted and drained with the object of preserving the dolomite support. The present Committee is of opinion that the cost involved would be out of all proportion to the benefit gained as the building is ramshackle and cracked. Moreover there is no certainty of the permanence of the protective works themselves. The area should, in the opinion of this Committee, be allowed to slip except in so far as the construction of bed bars in the Ballia ravine may stop slipping. But the hillside should be watched and the occupants of the building warned every rains, as at present, that they occupy it at their own risk.

Government asked for a project for the drainage of the subsiding area on Depot Road ; the work was estimated to cost Rs.20,000, but there was never any likelihood of so large a sum being found for it and nothing has been done. In the meanwhile the road has been metalled at the expense of the Army Department and the construction of bed bars in the Ballia ravine, which have prevented scour at critical points, has stopped subsidence of the hillside during the rains.

This Committee is of opinion that for areas bordering the Ballia ravine all that need be done for the present is to construct bed bars, where required, in the stretch of the ravine between the end of the lined portion and the Motapani Stream. The total cost of the work is estimated to be Rs.70,000, but the expenditure might be distributed over 10 years. The 1927 Committee in their proposals 5 and 6 recommended an annual expenditure on bed bars in this length of the Ballia ravine and Government accepted the recommendation but, due to financial stringency, bed bars have been put in only when and where there has been excessive scour.

If after a year or two no further subsidence is observed in Depot Road a diversion should be made by cutting into the hillside. A level road can by this means be obtained at a cost of about Rs.12,000 and will ensure the distribution of drainage over the subsided area. There is at present, due to the subsidence in the road, a tendency for storm water to collect at the lowest part and be discharged on to the slip. Although the slip appears to have settled down it would be advisable to stop this concentration of water being discharged on to it. Moreover the present deep dip in the road causes some inconvenience to motorists.

Proposal (9)—Durga Cottage has been demolished and the area on which it stood sloped off. That area is now covered with shrub, but there has been no afforestation.

Proposal (10)—The Municipal Board have not given effect to the proposal to slope off the tennis court at Fair Light Hall or provide it with a rammed clay foundation. This Committee considers that the danger pointed out by the 1927 Committee still exists, and that the action recommended by that Committee should be taken.

Proposal (11)—Adequate drainage has been provided above Mal-lon Cottage ; a new drain was built in 1927 at the cost of Rs.2,000 and is serving its purpose. But the Municipal Board have not had the vegetables garden at St. Cloud sloped off as suggested. This should be done.

Proposal (12)—The question of draining Sukhatal was shelved because the Superintending Engineer, Public Health Department, was opposed to the proposal as affecting the springs supplying Naini Tal with water. This Committee does not believe that there would be any danger to the buildings immediately below Sukhatal due either to the bursting of the scree dam or to Sukhatal overflowing, and agrees with the Superintending Engineer, Public Health Department, that no steps should be taken to drain it. In connection with the possibility of Sukhatal overflowing, it may be mentioned that the highest level to which water has risen since the gauge was fixed, was 25 feet 5 inches in 1932. The level of the water was then about 15 feet below the top of the dam.

Proposal (13)—This was not a very practical suggestion. It has been quite impossible for the Public Works Department to locate leakage from the lake alleged to take place under Wargrave House and the Chase.

Proposals (14) and (15)—Afforestation is not within the terms of reference of this Committee and is being dealt with by a Forest Officer, but it may be mentioned that a bad slip on Manora hill might block the Durgapur ravine and cause scour at the toe of the bluff on which the power house stands.

Item (c) Observation stations and need for additional stations

As recommended by the 1927 Committee new base lines have been fixed and rules and forms relating to the recording of observations have been printed in Chapter III of the Government publication known as "Regulations in connexion with hillside safety and lake control, Naini Tal". Two overseers were employed on making observations prior to 1932 but, due to a reduction of staff in 1933, it has not been possible since then to spare more than one overseer for the work. Since 1933 there has been no extra Assistant Engineer at Naini Tal and the Assistant Engineer incharge of the District has checked observations made by the overseers as often as possible. This Committee considers that in the interest of obtaining accurate records the recommendations of the 1927 Committee in regard to the taking of observations by two overseers should be given effect to.

All the additional pillars recommended by the 1927 Committee have been erected by the Public Works Department except those at Matyali and Amparao. This Committee is of opinion that there is no need for observation pillars at the two places last named, as there is no likelihood of loss of life due to movement of the hillsides.

The Public Works Department have also built an observation hut in the grounds of Brookhill House to take the place of the open post at Jesmond Villa.

Item (d) Lake regulation and authority for control of the same

The recommendations of the 1927 Committee have been given effect to and this Committee has no further remarks to offer.

Item (e) Authority for excavation, building and tree cutting

In the "prohibited" area the Executive Engineer, Kumaun Division, is the controlling authority but in the "exempted" area that authority is vested in the Municipal Board. The Executive Engineer is an *ex officio* member of the Board and is elected President of the Public Works Sub-Committee which deals with applications for excavation, building and tree cutting. He therefore is in a position to advise the Board on these matters, but there have been instances where he has been out-voted and his advice ignored. The exempted areas do not contain dangerous hillsides and therefore neglect of the Executive Engineer's advice would not produce a major catastrophe, but it has, in the past, led to unnecessary disturbance of hillsides, the construction of weak revetment walls and an inadequate provision for drainage. The resulting collapse of structures has blocked roads and drainage lines and led to damage which has had to be made good at public expense. Since the Public Works Department maintain the drains (from Provincial funds) and the roads (from Municipal funds) in the "exempted" area, and since damage to hillsides even in this area must be made good from Provincial funds due to the inadequacy of the Board's resources, it is reasonable to suggest that the Executive Engineer should be the controlling authority for the "exempted" area as well. The bazar area, which has now been fully built on and moreover, is comparatively flat, should be excluded and remain under the control of the Board as at present. It is believed that the Municipal Board would not oppose such a suggestion. It was made by the 1927 Committee, except that no mention was made of leaving the bazar area under the control of the Board, but Government apparently did not approve, due possibly to opposition from the Board, as in G. O. no. 2386/XI—48F, dated the 26th September, 1930, they only increased the extent of the "prohibited" area.

This Committee, for reasons already mentioned, supports the recommendations of the 1927 Committee, except that it thinks the bazar area should be left under the control of the Municipal Board, and suggests that the question may be re-opened with the Board.

The 1927 Committee also recommended the reintroduction of the 4 acre rule; a suggestion which was not approved by Government. If the Executive Engineer is constituted controlling authority for all areas other than the bazar area there will be no need for the re-introduction of this rule, otherwise its need in the "exempted" area is a real one, for there has been a distinct tendency to overcrowding in this area in recent years, due to the demand for smaller houses.

Item (f) Rainfall, run-off, assessment of normal leakage and evaporation, and fixation of a reasonable figure for run-off

The recommendations of the 1927 Committee with regard to the observations to be made and the form in which they should be recorded have been published in Chapter II of "Regulations in connexion with hillside safety and lake control, Naini Tal" and have been carefully

followed. This Committee however does not agree with the 1927 Committee that the percentage "run off", as calculated, is any indication of "the efficiency of the surface drains and therefore a measure of the general stability of the hillsides". A note has been appended, (Appendix C) showing the large variation obtained in percentage run off from year to year and the dependence of that figure not only on rainfall but on the sequence of dry and wet years. Since 1929, from which year observations have been made as required by the 1927 Committee the percentage has varied from 36 to 90. It is therefore wrong and misleading to fix a percentage as an index of the safety of the hillsides.

But this Committee recommends that the data, which are useful for a variety of purposes, should continue to be collected.

Item (g) Verification of the catchment area and whether the Sukhatal area should be included or not

Item (h) Method of calculation of discharge

Item (i) Method of recording rain gauge readings

All the recommendations of the 1927 Committee have been given effect to.

Item (j) Removal of the large rock above the East Laggan road and near Killarny House

All the recommendations of the 1927 Committee have been carried out except that the large rock near pillar no. (B)(1) on Kalakhan hill has not been removed. As this rock is not in the inhabited area and its removal would be expensive, Government were of opinion that the work was not an urgent necessity. As far as can be ascertained the rock is in no more unstable condition now than it was in 1927. It should be watched, but there is at present no need for its removal.

Item (k) Periodical inspection of drains, etc.

Drains have been inspected and repaired regularly every year since 1927 and their general condition has improved. Some of them have been cement pointed or lined with cement concrete, and the Barna Nala, from the pumping station to its outfall at the lake, has been improved by constructing a cement concrete cumnette channel down the middle of its floor and cement pointing the sides.

Item (l) (i) Examination of Charta Hill

Charta Hill continues to show movement during the rains, the extent of which varies with the quantity and intensity of rainfall, and minor slips occur; wide cracks still develop in the rainy season on the face of the slipped area. The usual observations are made.

Some large movements were noticed in 1932 but at no time since 1927 has the situation really become alarming. The 30 feet span, deep foundation, bridge at the Brewery in mile 76 furlong 6 of Bareilly-Ranikhet road has stood well and communications have not been interrupted or indeed threatened by slips from Charta Hill. All movement so far has been very local. An interesting fact, which may be mentioned is that a defined channel has formed in the face of the big slip and water

flows down to the Brewery and under the 30 feet span girder bridge into the Ballia ravine. The only possible danger to communications will arise if at any time this channel is blocked by slips and the water is diverted. There is however no immediate danger of this happening.

Item (1) (ii) Examination of Amparao

The protective works carried out in Amparao from 1925 to 1928 appear to have been an unqualified success as the area seems to have settled down and is now giving no trouble. Road subsidence has since 1927 been very small and for the last seven or eight years there has been no subsidence at all. Whereas Amparao used to figure prominently in the monsoon, damage estimates in the past, for the year 1936-37 with an abnormal rainfall of 140 inches causing heavy damage, elsewhere no provision was made for repairs at Amparao.

The scene of trouble has shifted to Matiyali about half a mile lower down the cart road. For six or seven years past the hillside has developed cracks, the road has subsided and revetment walls have been damaged. Last rains about 15 feet of road at the lower hair pin bend with a 30 feet high revetment wall built the previous year subsided about 15 feet. The road has now been set back and some protective works in the form of toe walls and drains have been carried out. It remains to be seen what happens this year and how effective those works prove, but it is feared subsidence will continue.

It may be mentioned that the cultivated areas above the road at Amparao known as Dangar village have been acquired and the portion below the road at Matiyali known as Matiyali village and all cultivation has been stopped.

There is still a cultivated area at the top of the hill above the Matiyali hair pin bends. It is recommended that that area should also be acquired in order to stop its cultivation. It is also recommended that the slipped area at Matiyali should be afforested.

Since the 1927 Committee met there has been no change in the condition of hillsides requiring specific mention other than the subsidences at Matiyali which have been referred to above, but a list of the small slips and falls of boulders which have occurred since that year, is attached to this report as Appendix D.

A list of tennis courts constructed since 1927 is also attached (Appendix E). Out of 16 courts only one, that at the End Cliffe, has been constructed in the dangerous area. Its situation however is not such as to cause anxiety.

Reconstruction of the Kumaun Division

The 1927 Committee was of opinion that the charge of the Executive Engineer, Kumaun, was too heavy to permit him to exercise sufficient supervision over security work at Naini Tal. They therefore recommended:

(a) That the Dehra Dun Division should be re-opened and should take over the Garhwal District.

(b) That the Kumaun Division should be divided into two, or at the very least,

(c) That the post of District Engineer, Naini Tal, should be re-created and a senior officer of the rank of Assistant Executive Engineer appointed to it.

Not only did Government not approve of any of these suggestions, but they subsequently combined the charges of Kumaun and Bareilly divisions.

This Committee is of opinion that the duties of the Executive Engineer, Kumaun, are now far heavier than they were in 1927 and that it is quite impossible for him to give adequate personal attention to security work at Naini Tal. Moreover, apart from the heaviness of the present charge, there is the necessity for the Executive Engineer to inspect road work in the plains during the rains at a time when it is vitally important that he should be in Naini Tal. This Committee recommends that the Executive Engineer, Kumaun, should be relieved of the charge of the former Bareilly Division so that he can devote more time to the supervision of security work at Naini Tal. The responsibility is his, but, due to the pressure of other work and the necessity of frequent inspections in the plains, he can only give nominal attention to these very important duties and cannot exercise the check recommended by the 1927 Committee.

4. *Movement of hillsides since 1927*—The statement in Appendix F to this report compares observed movements in hillsides during the past ten years with those in the previous ten years. It will be noticed that there has been very little movement within the lake area during the past ten years and that movement generally has been less than during the previous ten years. Outside the lake area there has been considerable movement during the past ten years in Kalakhan hill, the old police lines spur, the main fissure on Kalakhan hill, the Depot road and Charta hill, but, where figures exist for the period 1917-26, it will be seen that movement in those ten years was greater.

5. *The capacity of the lake to meet the demands of the hydro-electric and water supplies* (1) *Factors affecting dry weather supply*—There is never any fear of the lake not being filled by the monsoon for, even in the driest years, it is found necessary to discharge large volumes of water through the sluices. The important matter for consideration, therefore, is the capacity of the lake to meet demands between the time it reaches full supply level, behind closed sluices and the time the next monsoon arrives; the table in Appendix G has been prepared to show the effect on the capacity of the lake of the important factors operating during that period. In that table are recorded the duration of the period referred to, the rainfall during that period and the rainfall during the previous monsoon. Good rainfall during the monsoon replenishes the springs and slows up the fall in lake level during the following dry season, but if even a good monsoon ends early, and particularly if its successor starts late, the benefit is lost because of the longer period during which the stored supply is indented on. The length of the dry period is therefore a very important consideration. Rainfall during what has been called the dry period is another very important factor, for during the past twelve years it has varied from 5.63 to 28.14 inches.

The effect of these factors on the level of the lake has been explained in the remarks column of the table year by year, but a comparison of the figures recorded against the years 1928, 1932 and 1935 will probably best illustrate their action.

1928. The previous monsoon (142·77 inches) was the best in the 12 years considered and the winter rains (21·02 inches) were very good. The dry period (237 days) was comparatively short and at the end of it the level of the lake stood at 7·80, above the intake the highest recorded in the table. All the conditions were favourable.

1932. The previous monsoon (80·42 inches) was about the lowest in the 12 years and the winter rains (5·63 inches) quite the lowest, but the dry period (236 days) was comparatively short, and so the level of the lake (5·20) did not fall as much as might be expected. Rainfall was very unfavourable but the situation was saved by the short interval between monsoons.

1935. The previous monsoon (105·19 inches) and winter rains (12·29 inches) were much better than for the year 1932 and yet the level of the lake fell to 4·30 or nearly a foot lower than in 1932. This is explained by the long dry period, 273 days.

(2) *Dry weather, 1934-35*—Since the lake reached the lowest level on record in 1935 it would be as well to examine in detail the withdrawals and losses during the dry period 1934-35. They are recorded below in lakhs of cubic feet.

	Hydro-electric supply	Unfiltered water supply	Town supply	Leakage (springs)	Loss due to evaporation	Total
October ..	36·72	0·29	11·09	161·82	15·00	224·92
November ..	34·11	0·26	7·13	103·80	15·00	160·30
December ..	34·44	6·24	5·62	74·40	10·00	130·70
January ..	35·16	0·00	6·22	74·76	10·00	126·14
February ..	30·93	0·13	5·01	67·32	10·00	113·39
March ..	32·98	0·38	7·26	72·45	20·00	133·07
April ..	35·93	0·68	9·50	53·84	25·00	124·95
May ..	43·70	1·07	14·27	51·00	40·00	150·04
1st to 15th June ..	22·49	0·56	7·15	16·90	10·00	57·10
	306·46	9·81	73·25	676·29	155·00	1220·61

The contours of the lake below level 5·00 on the hydro-electric gauge have unfortunately not been recorded but, assuming that there is no great difference in the slope of the hillsides above and below that

level, the volume of water stored between level 4.30, to which the surface of the water fell, and 0.00, which is the level of the hydro-electric intake, is found to be 200.54 lakhs of cubic feet :

		Gauge readings	Volume of water in lakhs c.ft.
Taken from Coulson map	..	12.00 to 11.00	49.89
		11.00 to 10.00	49.69
		10.00 to 9.00	49.33
		9.00 to 8.00	49.00
		8.00 to 7.00	48.63
		7.00 to 6.00	48.16
Estimated	..	6.00 to 5.00	47.80
		5.00 to 4.00	47.45
		4.00 to 3.00	47.10
		3.00 to 2.00	46.75
		2.00 to 1.00	46.40
		1.00 to 0.00	46.05

Volume of water between 0.00 and 4.30.

$$=46.05+46.40+46.75+47.10+0.3 \times 47.45.$$

$$=200.54 \text{ lakhs cubic feet.}$$

Had the monsoon been delayed and withdrawals and losses continued at the rates recorded for the first half of June there would have been sufficient water above the intake to keep the hydro-electric installation working for $\frac{200.54}{2 \times 59.1} = 1.7$ months or till the 6th of August. It is most unlikely that there would have been no rain by that date and moreover the level of the intake can be lowered as it is $3\frac{1}{2}$ ft. above the crown of the pipes, but the surface of the lake cannot be permitted to fall much below level 4.30 without making Naini Tal unhealthy and ruining the amenities of the town.

Further there were 12.29 inches of rain during the dry period 1934-35. This indicates a receipt of $12.29 \times 38.03 = 467.39$ lakhs cubic feet of water on the catchment. Had the rainfall been only half what it actually was the loss to lake storage would have been about $\frac{467.39}{6} = 77.9$ lakhs cubic feet assuming that only one-third of rainfall is available for storage. This means that the supply would have lasted $\frac{200.54 - 77.9}{2 \times 59.1} = 1.04$ months longer or till about the 16th of July, unless the intake channel had been lowered.

(3) *Leakage from the lake*—It has been suggested from time to time that leakage from the lake has increased. The only means of investigating the possibility of increased leakage is to study the discharges from springs below Talli Tal. This has been done, but the inferences drawn from the records are so contradictory that this Committee is not prepared to express an opinion on the subject.

(4) *The lake is being drawn on practically to the full extent contemplated when the hydro-electric project was prepared*—The level to which the lake fell in June 1935 is an indication that the limit to which it may be drawn on during the dry months, has, for all practical purposes, been reached and this conclusion is supported by the comparative figures given below. They show that during the dry months of 1934-35 the hydro-electric installation generated 46·6 per cent. more units and consumed 86·1 per cent. more water than was contemplated when the project was prepared. This was possible principally because losses due to evaporation, absorption and leakage, together with the small consumption by water supplies, had been greatly overestimated. Some additional water was available because the overflow level of the lake had been raised. It will be noticed that the lake fell 7·63 feet leaving a depth of 4·3 feet above the intake whereas it was contemplated that it would fall 7·15 feet leaving a depth of 3·5 feet above the intake.

Serial number	Particulars	Estimated in project 1919-20	Actuals 1st October 1934 to 15th June, 1935	Percentage increase
1	Total quantity of water used for hydro-electric installation during 8½ dry months, i.e. from 1st October to 15th June.	170·00 lakhs c.ft.	306·46 lakhs c.ft.	86·1
2	Total units generated during 8½ months.	560·000 ..	820,948* ..	46·6
3	C. ft. of water per unit generated.	30·36 ..	37·33 ..	23·0
4	Drop in lake level between maximum and minimum.			
	(a) Due to hydro-electric supply.	3·40 ft.	6·24 ft.	..
	(b) Due to evaporation, absorption, leakage and water supply.	3·75 ft.	1·39 ft.	
		} 7·15		} 7·63
5	Minimum lake level ..	3·5	4·3	

*The corresponding figure for the year 1936-37 is 971,869 units.

(5) *Suggested minimum lake levels and a supplementary supply*—This Committee is of opinion that the demand on the lake, by the hydro-electric installation should not be permitted to increase. If Naini Tal is abandoned as the summer Headquarters of Government the consumption of electric current will probably decrease, at any rate for a few years, but the time appears to have come when Board should consider ways and means of supplementing the present supply. This can be done:

- (a) by raising the full supply level of the lake,
- (b) by utilizing water from the springs below Talli Tal,

- (c) by installing an auxiliary power plant, or
- (d) by taking power from an outside source.

(a) would be costly as its adoption would mean the raising parts of the Mall and some boathouses, and is probably out of the question because it would lead to the flooding of the temple at Malli Tal.

The comparative merits of (b) and (c) depend on their capital and running costs.

(d) would be feasible if an electric grid were constructed in Kumaun.

As a guide to the Municipal Board this Committee has prepared a graph (Plan No. 2) showing the minimum level to which the lake may be permitted to fall on the 1st of each month. It is based on curves showing lake levels throughout the year during the past ten years. A plan (No. 3) showing those curves as well as curves for rainfall in those years is also attached to this report.

6. *Summary of recommendations by the Technical Committee.*

(1) *Protective works*—(a) The drainage system should be improved—

(i) by lining the ravine from Snowdon to Sleepy Hollow where it joins drain No. 35 ;

(ii) by lining the unlined portions and drains nos. 3, 4 and 5 of Sher-ka-Danda hill. The approximate cost of these works is Rs.5,000.

(b) The improved trenches and barriers above the Upper Cheena Mall should catch all falling boulders in future. If not, a second line of defence will have to be constructed.

(c) Bed bars should be constructed in the Ballia ravine where required, from the Fairy Hall drain to Motapani stream. The cost of this work is estimated at Rs. 70,000 but expenditure might be spread over 10 years.

(d) No expenditure is recommended on revetment walls and drains on the Gangipur spur.

(e) If there is no further subsidence on the Depot Road a level diversion should be constructed by cutting back into the hillside. Approximate cost Rs.12,000.

(f) The tennis court at Fairlight Hall should be provided with a rammed clay foundation or sloped off.

(g) The vegetable garden at St. Cloud should be sloped off.

(h) The large rock near pillar no. B(1) on Kalakhan hill need not be removed.

(i) Cultivation at the top of the hill above the Matyali hair pin bends should be stopped and that area drained. The subsiding area at Matyali should be afforested.

(2) *Observations of movements of hillsides*.—Two overseers should be employed in making the observations.

(3) *Authority for excavation and building and tree cutting*.—It is suggested that the Executive Engineer, Kumaun Division, should

be the controlling authority for all areas except the bazaar area. If this is not agreed to, the 4 acre rule should be re-introduced in the "prohibited" and "exempted" areas.

(4) *Rainfall run off, etc.*—It is unnecessary to calculate "percentage run off". That figure is not an index of the safety of the hill-sides and is misleading. But the data collected are useful for a variety of purposes and should continue to be recorded.

(5) *Reconstitution of the Kumaun Division.*—The Executive Engineer, Kumaun, should be relieved of the charge of the former Bareilly Division.

(6) *The lake*—(a) Contour levels should be taken down to the intake of the hydro-electric installation and capacity computed for each foot of level.

(b) The ridge in front of the intake should be cut through to provide free access of water.

(c) The hydro-electric installation has worked up to practically the full demand on the lake contemplated when the project was prepared. Any increase in the supply of electric energy should therefore be met—

(i) by taking water from the springs below Talli Tal,

(ii) by installing an auxiliary power plant, or

(iii) by taking power from outside.

(d) The level of the lake on the 1st of each month should not be permitted to fall below the level shown in plan no. 2.

F. D. TUNNICLIFFE,

Superintending Engineer,

Public Health Engineering Department,

9-6-37.

L. B. GILBERT,

Superintending Engineer,

II Circle, Provincial Works,

9-6-37.

M. S. BISHT,

Assistant Engineer, Naini Tal.

9-6-37.

APPENDIX A

LIST OF DRAINS

(For drains constructed before 1927 see Appendix A to the Report of the 1927 Committee)

Drains constructed since 1927 are mentioned below :

1. *Maldon Cottage drain* (1927)—This drain was constructed to take off the drainage of the area round and above Maldon estate, as suggested by the 1927 Committee. Its length is 4 ch. 70' ($1\frac{1}{2}' \times 1\frac{1}{2}'$) and it cost about Rs.2,500.
2. *Branch of drain no. 21 below Charlton Lodge* (1929)—This drain was constructed to replace a kachha drain. Length—118, ($2' \times 1\frac{1}{2}'$), cost about Rs.350.
3. *Branch of drain no. 31 on Cheena Hill* (1930)—This drain was constructed in 1930 to prevent erosion of the hillside. Its length is 76' and it cost Rs.150.
4. *Branch of drain no. 23 on the Eastern side of Blythe Cottage* (1931)—Length 3ch. ($1\frac{1}{2}' \times 1\frac{1}{2}'$). It was constructed to replace damaged drain and cost about Rs.500.
5. *Haribhawan drain* (1932), $4\frac{1}{2}$ ch. ($1' \times 1'$)—This drain was constructed by the owner of Haribhawan at a cost of Rs.700 to take the extra drainage from Haribhawan and present slips.
6. *Branch of drain no. 34 near Sleepy Hollow* (1930), 170 ($1' \times 1'$)—This drain was constructed to replace the unlined portion of drain no. 35. Cost about Rs.300.
7. *Drain behind Hawksdale*, 1932—This drain was constructed for the safety of the hillside behind Hawksdale and to take the drainage of the hillside above (4ch. $\times 1' \times 1'$).
8. *Branch drain between Ramsey Hospital and Lower Danda* (1936)—250' long ($3' \times 2'$). This drain was built to prevent scouring in the ravine which was endangering the hillside. Cost Rs. 800.

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6. *Branch of drain no. 34 near Sleepy Hollow* (1930), 170 ($1' \times 1'$)—This drain was constructed to replace the unlined portion of drain no. 35. Cost about Rs. 300.
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4. *Branch of drain no. 23 on the Eastern side of Blythe Cottage* (1931).—Length 3 ch. ($1\frac{1}{4}' \times 1\frac{1}{2}'$). It was constructed to replace damaged drain and cost about Rs.500.
5. *Haribhawan drain* (1932), $4\frac{1}{2}$ ch. ($1' \times 1'$).—This drain was constructed by the owner of Haribhawan at a cost of Rs.700 to take the extra drainage from Haribhawan and present slips.
6. *Branch of drain no. 34 near Sleepy Hollow* (1930), 170 ($1' \times 1'$).—This drain was constructed to replace the unlined portion of drain no. 35. Cost about Rs.300.
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APPENDIX B

COMPLETE LIST OF PROTECTIVE WORKS IN THE LAKE AREA

I—Sherkadanda Hill

1. Adits nos. 1, 2, 3, 4 and 5.
2. Protective works on 1880 slip.

These are retaining walls near Maldon estate, above Bank house, above Kumaun Lodge and on the Upper Cheena Mall below Loyal Road.

*R. Walls and underpinning near Braemar.

II—Bara Nala System

1. Adit below St. Helens.
2. Barriers above the Upper Cheena Mall, behind Oakpark, Melrose, Balmoral and Stafford House, and above Tonochy Road.
3. *Barriers above the Upper Cheena Mall.
4. *Underpinning walls above and below Hermitage Road.

Ayarpatta System

1. *Barriers and protective works above the Upper Ayarpatta Mall, above St. Andrews, Edwinstowe, and Emily Lodge.
2. *Walls below Edwinstowe.
3. *Underpinning walls above East Lagoon Road near Craig Ellachi.
4. *Masonry shoots on the South Mall.
5. *Walls behind Hawksdale beyond the Lake basin system. Walls below Bellevue and above the Jail.

NOTE—Protective works marked* have been carried out since 1927.

APPENDIX C

FIXATION OF A REASONABLE FIGURE FOR RUN-OFF

Against item (f) of its terms of reference the 1927 Committee said :

"If the annual statements are extracted on the above principle the Committee agree that the figure of 70 per cent. run off from the hillsides arrived at by them is the true index figure which can be taken as a measure of the efficiency of the surface drains and, therefore, a measure of the general stability of the hillside. This percentage will vary with the amount and nature of distribution of the rainfall, chiefly during the monsoon, and with the intensity of the heavier periods of rainfall."

The index figure is obtained as follows :

1. *Received on the hillsides*—Rainfall on catchment minus rainfall on surface of lake.

II. *Accounted for*—

- (a) Water taken for hydro-electric plant.
- (b) Town water supply.
- (c) Unfiltered water supply to Government House.
- (d) Leakage from the lake as measured by discharges of springs below Talli Tal.
- (e) Evaporation from the surface of the lake. This is an arbitrary figure taken as 175 lakhs of cubic feet for the year and distributed arbitrarily over the different months of the year.
- (f) Discharge through sluices.
- (g) Plus or minus the change in lake storage. An increase in storage is added, a decrease subtracted.
- (h) Minus rainfall on surface of lake.

(Strictly speaking an item should be added for evaporation and transpiration losses on the hillsides, but it is difficult to calculate these losses with any degree of accuracy and the 1927 Committee based its index of 70 per cent. for run off on data which did not include these losses.)

$$\text{Index figure} = \frac{\text{II}}{\text{I}} \times 100$$

The 1927 Committee realized that this percentage would vary within wide limits in the course of a year in accordance with the distribution of rainfall, but made the mistake of supposing that it would not vary greatly from year to year provided there was no marked change in the condition of the hillsides. As will be shown, it is not only the monthly figure that varies within wide limits; the annual figure also varies far too much to warrant its being taken as an index of any condition or conditions.

Since observations have been taken in the manner recommended by the 1927 Committee from the year 1929, the two following tables have been drawn up to show variations in the index figure during the period 1929-1936. The first table shows the index month by month for the years 1929, 1933 and 1936 and the second the yearly index for the period mentioned.

Monthly Index

Month	1929		1933		1936		Remarks
	Rain-fall	Index	Rain-fall	Index	Rain-fall	Index	
January ..	5.55"	30%	2.35"	131%	0.24"	779%	There was no rain-fall in November, 1929 or November, 1933 and yet water accounted for over and above that measured by the fall in the level of the lake was 82.01 and 132.89 lakhs cubic feet respectively.
February ..	0.13"	271%	4.52"	58%	2.14"	90%	
March ..	0.52"	238%	1.10"	277%	3.59"	53%	
April ..	1.75"	59%	4.58"	49%	0.66"	166%	
May ..	0.12"	110.8%	8.24"	33%	7.56"	34%	
June ..	13.89"	15%	16.49"	26%	23.76"	20%	
July ..	21.00"	9%	32.00"	81%	44.91"	60%	
August ..	24.61"	33%	22.43"	132%	29.82"	93%	
September ..	3.94"	87%	7.18"	156%	20.52"	98%	
October ..	2.85"	118%	14.26"	63%	0.99"	810%	
November ..	..	..	..	..	0.15"	2871%
December ..	7.50"	35%	0.04"	6567%	3.71"	82%	
Total ..	81.88"		113.19"		138.05"		

Yearly Index

Year	Rainfall	Index	Remarks
1929	81.88"	36%	
1930	104.88"	62%	
1931	80.41"	48%	
1932	133.74"	81%	
1933	113.10"	88%	
1934	105.19"	90%	
1935	79.79"	59%	
1936	138.07"	77%	

From the first table it will be observed that the monthly "run off" calculated in the way suggested by the 1927 Committee for annual run off may vary from 26 per cent. to 6,577 per cent. Moreover in November, 1929 and November, 1933 there was no rain and yet 82.01 and 132.89 lakhs cubic feet of water respectively were accounted for over and above that measured by the fall in the level of the lake. This means that the give and take from ground storage, or in other words the influence of the springs is so large that monthly figures of percentage run off mean nothing.

The second table shows that whereas the variation from year to year is not so great as the monthly variation, it is sufficiently wide to rule out percentage run off as an index of the safety of the hillsides. In eight years the percentage varied from 36 to 90.

The second table also shows the influence on the percentage run off of the sequence of wet and dry years. Rainfall in 1928 (104.53") was only fair and ground storage must have been heavily indented on before the rains of 1929. In this year the rains were very poor (81.88") and most of the water must have gone towards the replenishing of springs with the result that the percentage run off was only 36. In 1930 the rains were fair and the percentage run off went

up to 62. The rains of 1931 were very poor and the percentage fell to 48. The rains of 1932 were very good and the percentage rose to 81 in spite of replenishing springs, the effect of which is noticeable in the two succeeding years when in spite of the rainfall decreasing by 20.55" and 28.55", the percentage run off rose to 88 and 90. In 1935 the rains were very poor and the percentage dropped to 59. In 1936 they were very good and it rose again to 79 in spite of the replenishment of springs.

Clearly run off is no indication of the state of the hillsides and it is misleading to specify a minimum as an index of safety.

APPENDIX D

LIST OF SLIPS AND BOULDER FALLS

1928

1. Slip below the bridge at Dhobighat in the Ballia Ravine, west of Tara Lodge.
2. Falls of large boulders above Edwinstowe from above the Upper Ayarpatta Mall.
3. Falls of boulders from above Emily Lodge.
4. Falls of boulders from Cheena Hill.

1929

1. Falls of large boulders on to the East Lagoon and South Mall roads from Craig Ellachi.
2. Falls of boulders from Ayarpatta Hill near the Abbey.
3. Fall of boulders from Cheena Hill near the Toll Bar.

1930

There were no slips but some boulders came down from Cheena Hill.

1931

1. Small boulders came down on to the South Mall.
2. Falls of boulders from Cheena Hill.

1932

1. Slip above Hawksdale.
2. Slip of boulders and debries from Cheena Hill.
3. Slip of boulders behind Dufferin Lodge.
4. Slip in Charta Hill.

1933

1. Slip on Kalakhan Hill near pillar D2.
2. Falls of big boulders from Cheena Hill above drain no. 26B.
3. Fall of boulders from Cheena Hill near the Toll Bar.
4. Slip on the Upper Cheena Mall near Braemar.
5. Slip in the Ballia ravine below the Gangipur spur and on Kalakhan Hill opposite the Gangipur spur.

The first mentioned slip was of considerable dimensions and cracks appeared in the hillside above the slip and the grounds of the abandoned bungalow. There has not been any considerable movement since.

1934

1. Falls of small boulders on to the South Mall.
2. Falls of big boulders from Cheena Hill above drain no. 26B.
3. Slip on the left of main drain no. 26.
4. Slip at the toe of the Gangipur Spur.

1935

1. Falls of boulders from Cheena Hill above drains 26, 26B and from above Oak Park.

1936

1. Slip of boulders on Brinsop Road.
2. Falls of small boulders from Cheena Hill.
3. Falls of small boulders on to the South Mall.

APPENDIX E

LIST OF TENNIS COURTS BUILT SINCE 1927

Safe Area

1. Durga Niwas	..	..	..	..	..	1
2. Stawberry Cottage	..	..	..	..	..	1
3. Thanet Villa	..	..	..	..	..	1
4. Brookhill Lodge	..	..	..	..	..	2
5. Longdale	..	..	..	..	..	1
6. Chitrakut	..	..	..	..	..	1
7. Prasadavas	..	..	..	..	..	1
8. Balrampur House	..	..	..	..	..	2
9. Eastern Command by the lake side			..	..	..	2
10. Eastern Command above Depot Road			1
11. D. B. College		1
12. Puran Park	1

Dangerous Area

13. Endcliffe	1
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APPENDIX F

Statement of movements in different Spurs and Localities showing Total Maximum Horizontal and Vertical movements in ten years

Name of hill, spur or locality	Total maximum movements			
	1917	1926	1927	1936
	Horizontal	Vertical	Horizontal	Vertical
<i>Outside the lake area</i>				
1. Kalakhan Hill	23·05 ft.	14·56 ft.	7·38 ft.	3·87 ft.
2. Kaimukhet spur	Not observed.	..	1·18"	0·58"
3. Manora spur	Do. ..	..	0·42"	0·42"
4. Gangipur spur, upper pillar	Do. ..	..	0·72"	0·31"
4A. Ditto lower pillar (observed from Charta).	Do. ..	..	0·35"	0·84"
*5. Bellevue spur	Do. ..	..	0·09"	Nil.
*6. Old Reserve Police Lines spur	Do. ..	..	5·24"	3·26"
7. Charta Hill spur (below observatory)	Do. ..	..	0·40"	Nil.
8. Main fissure, Kalakhan Hill	3·50 ft.	3·49 ft.	3·40"	2·86"
9. Depot Road	4·60"	5·41"	3·80"	3·152"
10. Charta Hill, Upper Charta	The spur slipped in 1924.		16·56"	18·07"
11. Do. Lower Charta .. .. .	..	..	2·69"	4·03"
<i>Within lake area</i>				
12. Main fissure Sherkadanda Lala Durga Sah's tennis court.	2·17 in.	2·64 in.	3·09 in.	0·72"
13. Ditto at St. Cloud	3·25"	1·68"	1·06"	1·44"
14. Ditto Snow View	4·34"	4·80"	1·96"	1·76"
15. Ditto Old Government House	0·62"	1·08"	0·80"	1·20"
16. Edge Hill spur	13·82"	Not observed.	7·05"	Not observed
17. Ravenswood spur	23·46"	Do. ..	6·74"	Do.
18. Blythe Cottage spur	5·06"	Do. ..	0·65"	Do.
19. Alma spur	13·82"	Do. ..	8·05"	Do.
20. Galloway House spur	All new pillars.	Do. ..	2·52"	Do.
21. End Cliffe	Do. ..	Do. ..	1·09"	Do.
22. Glenlee	Do. ..	Do. ..	7·65"	Do.

* These two localities though outside the lake area are part of Naini Tal.

Year.	Rainfall in the preceding year	Rainfall since closing of sluices to 31st May, (Winter rains and summer showers)	Max. lake gauge at or after the closing of sluices	Lowest lake gauge in following summer representing height of lake surface above intake	No. of days during which sluices remained closed till rains broke	Total drop in gauge (Difference between full supply level and lowest level recorded)	Average drop per day = $\frac{7}{6}$	Remarks
1925	127.29	11.22	11.85 on (16th November).	7.20 on 8th June	208	4.65	.022	Previous monsoon very good therefore ground storage ample; winter rains fair. The period of withdrawal small, hence lake level high.
1926	99.50	21.73	11.1 on (11th October).	6.70 on 3rd July	273	4.0	.015	Previous monsoon below normal, but winter rains good. Though period of withdrawal high, lake level remained high.
1927	99.83	16.51	11.1 on (5th October).	6.85 on 1st June	254	4.25	.017	Previous monsoon practically the same as for 1926, winter rains lighter but period of withdrawal much less. Lake level higher than in 1926.
1928	142.77	21.02	11.75 on (18th October).	7.8 on 5th June	237	3.95	.016	Previous monsoon abnormal, winter rains very good. Period of withdrawal small, lake level highest on record.
1929	104.78	11.30	11.20 on (21st September).	4.95 on 11th June.	268	6.35	.024	Previous monsoon normal, winter rains fair, period of withdrawal high. Lake level very low.
1930	81.88	28.14	11.10 on (10th September).	6.30 on 13th June.	289	4.85	.017	Previous monsoon low, winter rains very good. Period of withdrawal very long, but level of the lake high.
1931	104.88	13.17	11.59 on (6th October).	4.70 on 8th July	249	6.89	.028	Previous monsoon normal, winter rains fair. Period of withdrawal small. Level of the lake very low.
1932	80.42	5.63	12.00 on (24th October).	5.20 on 15th June.	236	6.80	.029	Previous monsoon poor, winter rains very poor, but period of withdrawal low, and lake level higher than in 1931.
1933	133.74	23.84	12.04 on (25th October).	7.40 on 18th June.	237	4.64	.02	Previous monsoon very heavy, winter rains very good, period of withdrawal small. Level of lake high.
1934	113.19	7.02	12.12 on (6th November).	5.72 on 21st June.	230	6.41	.028	Previous monsoon just above normal, winter rains very low, but period of withdrawal small, and lake level higher than in 1932.
1935	105.19	12.29	11.93 on (27th September).	4.30 on 15th June.	273	7.63	.028	Previous monsoon normal, winter rains fair, period of withdrawal very long, lake level lowest on record.
1936	79.79	16.05	12.13 on (30th September).	6.10 on 16th May.	230	6.03	.026	Previous monsoon very poor, winter rains good, period of withdrawal small, level of lake high.

REPORT OF THE FOREST DEPARTMENT

No. 141/11—12, dated Naini Tal, July 21, 1937

From—F. CANNING, Esq., C.I.E., I.F.S., Chief Conservator of Forests,
United Provinces,
To—Secretary to Government, United Provinces, Public Works Department,
Buildings and Roads Branch

SIR,—With reference to the correspondence resting with your no. 785-C/48C-1936, dated July 15, 1937, I have the honour to submit Mr. Johri's report on the denuded areas in the catchment area of the Naini Tal Lake. I send also our forest map of the Naini Tal Settlement in duplicate.

2. Except in regard to the Manora and Charta hills the Conservator of Forests, Kumaun Circle, has nothing special he wishes to add to the report.

3. The points which have come to my notice are :

(a) The slopes of compartments 27 and 28.

The work of 1935 mentioned in the report was carried out at my instigation as having lived intermittently for some years below these slopes the damage done by falling boulders to the tree growth and the protective value of such growth was specially known to me. The work here requires continuous attention. It is not sufficient to plant for one year and then assume the area can be left for a considerable period. The damage from falling rocks is continuous, planting forms a cheap protective measure and should be equally continuous so long as there are places where trees can be sited.

(b) In prescribing future orders regarding felling of trees, I think, it is desirable to avoid unnecessary rigidity. Thus the views to be obtained from the walks in and about Naini Tal are one of the great attractions of the place and have a definite value to the municipality. If these are neglected, trees formerly too small to obstruct a view, rapidly grow up and the view is lost. I have recently arranged for clearing some views on the top or outer slopes towards the snows. In some of these cases topping and lopping, e.g. of oaks, suffices, in other fellings can be done and replanting of small trees to avoid creation of blank and to maintain stability of the hill side. This point of replanting small trees to replace large ones felled is, I think, a point that should not be overlooked. It is not desirable to have the station overwooded with large trees in dense crops but the other extreme of denuding the hills can be avoided if replanting is carried out concurrently with felling.

4. The main point, however, for which I have been holding up this report is regarding Manora and Charta.

These hills are not within the catchment area of the Naini Tal Lake, but have been mentioned in the past reports and are referred to again by Mr. Johri.

On reference to the Conservator of Forests, Kumaun Circle, I ascertained the existing orders regarding afforestation of these hills, vide Conservator of Forests, Kumaun Circle, no. 2571/XXXV--3, dated May 25, 1937, to the Executive Engineer, Kumaun Provincial Division, and its enclosures—copy sent herewith.

Without further enquiry we are not prepared to support further the view that protection including afforestation of these hills is not worth pursuing. The Conservator of Forests, Kumaun Circle, has asked the Divisional Forest Officer, Naini Tal, to report specially on the position in regard to these hills. I should like to await this report before giving a final opinion on this point.

I have the honour to be,

SIR,

Your most obedient servant,

F. CANNING,

Chief Conservator of Forests,
United Provinces.

REPORT ON THE DENUDED AREAS IN THE CATCHMENT AREA OF NAINI TAL LAKE

I—Geological formation and woody growth

There has been no change in the formation and woody growth since Mr. Kanjilal's report so they need not be repeated here.

II—Statement of denuded areas

Ayarpatta Hill—The portions below Dareham House, Langdale and Craig Cottage were found insufficiently wooded by Mr. Kanjilal; these areas are now

covered with shrubs and some trees but not yet sufficiently wooded. *No felling of trees should be permitted in the above areas elsewhere mature and dangerous trees may be permitted to be felled.*

Sher-ka-Danda—Alma Hill—The condition of woody growth over most of the estates mentioned by Mr. Kanjilal still remains unsatisfactory. No planting of trees or shrubs, etc. appears to have been done.

The eastern part of Sher-ka-Danda, viz. the area round about Ramsay Hospital, Stanley, Kapoor Lodge, Rohilla Lodge and the Nazul land of Rajpur requires special attention. Most of the estates on the Alma Hill are still sparsely wooded, but the apparently un-table area over Poplars and the Imperial Bank right up to the Maldon Estate calls for special attention.

Planting of trees and shrubs, etc. may be encouraged in the blanks all over the area and no felling of trees should be permitted here except in special circumstances.

China Hill—The upper portion of the slope in the Municipal Forest compartments 28 and 27. The formation here is very loose and unstable and boulders of all sizes are apt to roll down in the rains and cause serious damage to the bungalows situated below.

Protective works—Cross ditches and barrier walls to catch the falling debris and drains to collect and carry down the large volume of rain water during the rains have been constructed by the Public Works Department and afforestation of the area has also gone off and on for the last 30 years or so. *Regular afforestation is still urgently needed* and in 1935 the Municipal Board was persuaded to sanction an annual expenditure of Rs. 250 on this work. Since then over 7,000 plants and shrubs have been planted in compartments 27 and 28 and list *showing trees planted and survivals, etc. is given below :—

1935

Species planted	No. of plants planted	Number of plants now surviving		
		In good condition	Not surviving	Total
Horn beam transplants	225	20	..	20
Horse Chestnut transplants	201	73	3	76
Deodar ditto	447	165	15	180
Poplar transplants and cuttings	241	13	6	19
Maples transplants	89	30	5	35
Ash ditto	404	375	12	387
Alder transplants and cuttings	134	..	..	..
Rhododendron transplants	11	..	..	..
Cypress transplants	126	21	1	22
Willow cutting	80	..	..	..
Machilus spp. transplants	10	..	..	..
Total	1,918	696	42	738
SHRUBS				
Viburnum transplants	683	215	..	215
Desmodium ditto	121	35	..	35
Indigofera ditto	66	..	..	..
Wikstromia ditto	80	27	..	27
Spiraea ditto	959	60	..	60
Tung ditto	50	14	..	14
Arundinaria ditto	850	185	..	185

1936

Compartment no.	Species planted	No.
27	<i>Trees spp.</i>	
	Deodar	45
	Cypress	181
	Ash	48
	Horse-chestnut	1
	Maples	28
	Total	248

*Divisional Forest Officer,
Naini Tal, no. 844/xxx
—10, dated September
30, 1936.

Compartment no.	Species planted						No.
27	<i>Shrubs</i>						
	Viburnum	..	..	..	..	..	382
	Jasminum	..	..	..	..	..	65
	Wikstromia	..	..	..	..	..	516
	Dhalout	..	..	..	..	..	83
	Total						1,081
29	<i>Trees spp.</i>						
	Maples	..	..	..	..	..	48
	Horse-chestnut	..	..	..	..	..	5
	Ash	..	..	..	..	..	102
	Cypress	..	..	..	..	..	190
	Deodar	..	..	..	..	..	101
	Total						446
	<i>Shrubs</i>						
	Viburnum	..	..	..	..	..	259
	Wikstromia	..	..	..	..	..	422
	Jasminum	..	..	..	..	..	398
	Desmodium	..	..	..	..	..	28
	Arundinaria	..	..	..	..	..	1,091
	Dhalout	..	..	..	..	..	79
	Total						2,177

It will be seen that Ash (*angu*) has shown the largest percentage of survivals so far and may prove very suitable for planting specially in the upper portions. Decdar, maple and horse-chestnut have also given good results, but cypress may still be considered the best tree for this area, because once it is established it regenerates itself easily.

Of the shrubs—Viburnum, Arundinaria, Wikstromia, Spiraea and Desmodium have given good results and should be tried again.

All blanks in the area are being filled in but the area between Oak Park and China Forest Chauki requires special attention.

III—Nursery

The present Municipal nursery lies in a far away place below the Alma Peak and contains only about a thousand cypress and few deodar seedlings. It should be extended to have a larger stock of all the species recommended, viz., *angu*, deodar, cypress, and horse-chestnut, etc. There is a small nursery near the Tonnochy Forest Guard Chauki also, but nothing is being done there.

IV—Recommendations of the last Hill-sides Committee

Except for some restriction on the fellings of trees hardly anything appears to have been done to carry out the recommendations of the last Committee.

The condition of the denuded estates and nazul lands is much the same as before and the so-called municipal nursery lying in a far away corner and selling a few plants at 2 annas each is hardly of any public good.

All these recommendations are likely to remain mere pious hopes unless the Municipal Board is prepared to maintain at least one well stocked nursery and to undertake planting work in the station realising all the cost of the work from the estates concerned.

V—Manora and Charta Hills

These hill-sides are practically bare, there is very little soil cover and only a few trees and shrubs are scattered here and there.

Afforestation work is urgently needed here, but only regular and continuous work for a fairly long time will be of any good; for this a good nursery in a central place is the first necessity.

Chir sowings in the upper part, on spurs and ridges and on all exposed soils showing signs of stability are recommended and Poplars and *Qadrella serrata* may be tried lower down.

Pan-bhabar grass has been put in small patches in the past and is doing well; it should be tried again and on a larger scale.

Also the whole area should be strictly fire-protected and closed to lopping, grazing (specially goat and sheep grazing), grass cutting and quarrying.

G. M. JOHRI,
Working Plan Officer,
Naini Tal Working Plans Division, U. P.

Copy of letter no. 2571/XXXV-3, dated May 25, 1937, from the Conservator of Forests, Kumaun Circle, to the Executive Engineer, Kumaun Provincial Division, Naini Tal.

WITH reference to your no. 2752/N-4-MW., dated April 26, 1937, to the Chief Conservator of Forests, United Provinces, I have the honour to enclose herewith a copy of G. O. no. 74/339W-1926, dated March 3, 1931, to the Chief Engineer, United Provinces, Buildings and Roads Branch. In view of that G. O. no further action was taken by this department.

Copy of G. O. no. 74/339W-1926, dated March 3, 1931, from the Public Works Department, Buildings and Roads Branch, United Provinces, to the Chief Engineer, P. W. D., Buildings and Roads Branch.

SUBJECT: *Afforestation of the slipped areas of Manora and Charta Hills*

WITH reference to the correspondence ending with G. O. no. 293C/C-339W-1926, dated May 15, 1930, I am directed to invite your attention to items b(14) and (15) of G. O. no. 377-C/339W-1926, dated December 17, 1929, and to say that since afforestation is not likely to affect the deeper movements, nor to prevent half the hill-side coming down as it did in 1924, the Government consider that the idea of undertaking it as a measure of protection to the road is not worth pursuing. On the other hand, the Government think that a warning to the inhabitants of the grave risk that they run by remaining on this dangerous hill-side should be given and they are asking the Commissioner to do this.

No. 75-C

Copy forwarded to the Commissioner, Kumaun Division, for information, with reference to his letter no. 418/XXIV-14 dated October 31, 1930, and with the request that he will kindly issue necessary instructions to the Deputy Commissioner to warn the residents of the grave risk that they run by remaining on this dangerous hill-side.

By order,
A. R. BURNS,
Assistant Secretary.

No. 2242/XXIV-14

KUMAUN COMMISSIONERSHIP

Dated Haldwani, March 17, 1931

Copy forwarded to the Deputy Commissioner, Naini Tal, for information and compliance, with reference to his no. 4397/XXIV-18, dated August 2, 1930.

N. D. UPRETI,
HEAD ASSISTANT,
For Commissioner.

No. 313/11-12, dated Naini Tal, August 14, 1937

From—F. CANNING, ESQ., C.I.E., I.F.S., Chief Conservator of Forests, United Provinces,

To—The Secretary to Government, United Provinces,
Public Works Department, Buildings and Roads Branch.

SIR,—WITH reference to G. O. no. 978-C/43C-1936 of August 8, 1937, I have the honour to send herewith the report of Conservator, Kumaun Circle.

2. The proposal of 1930 for evacuation of the villages and afforestation of the area made by the Divisional Forest Officer, Naini Tal, and supported by the Conservator (Mr. Cooper) after inspection on the spot was not agreed to by the Commissioner and was therefore not then sent up by me.

3. On the other hand the Deputy Commissioner, Naini Tal, purchased a chak called Alukhet at a cost of Rs 5,322 without reference to the Conservator, Kumaun Circle, and without any arrangements having been made for provision of funds and the expenses were debited to the Forest Department, Kumaun Circle.

4. My conclusions are that unless the unsafe areas on Manora and Charta Hills affect the safety of the Naini Tal Power House, the municipality is not particularly interested in what happens to them. The Forest Department has no object in spending money on these areas for the point of view of

advantage to the Department. If evacuation, acquisition and protection of the areas is desirable this appears to be a matter for the decision of the district officials and the Public Works Department. The Forest Department could take over any areas acquired for protection purposes and be entrusted with their protection and afforestation. Costs of acquisition should not be borne by the Forest Department but those of afforestation and maintenance could conveniently be included in the Forest Department budget.

5. I agree with the Conservator, Kumaun Circle, that without careful consideration of the problem on the spot it is difficult to express any definite opinion on the value of afforestation. I may add that some years ago I tried with the Commissioner of Kumaun to inspect areas in this locality during the rains and we found it was practically impossible to do it at that season and had to leave the inspection until after the monsoon.

Generally speaking afforestation is recognized as a protective measure for hill-sides. Afforestation would almost certainly involve some extent of evacuation and compensation for existing rights. Provision of alternative village sites and cultivation has been found to present great difficulties but if the protection of these hills is desirable I think we should not abandon the idea on account of anticipated difficulties without very thorough investigation.

6. It would appear however that the Manora slip area already lies within municipal limits and it might be possible to try the results of closure and afforestation here without the expense and difficulties of acquisition and evacuation.

7. Also the results of the acquisition of Alukhet should be seen and taken into consideration by the Committee.

I have the honour to be,

SIR,

Your most obedient servant,

F. CANNING,

Chief Conservator of Forests,
United Provinces.

Report no. 412/XXXV—3, dated Naini Tal, August 13, 1937.

CHIEF CONSERVATOR OF FORESTS, UNITED PROVINCES—

Reference your no. 142/11-12, dated July 21, 1937, and the enclosed, which I return in original. I enclose herewith a copy of the Divisional Forest Officer, Naini Tal's no. 343/XXXV—10, dated August 10, 1937, together with a tracing of the area concerned. I also enclose an extract copy of the rights list of the Nalena Block. The proposal to acquire the villages in this area was submitted to you under cover of this office no. 904/XXXV—3, dated November 13, 1930. I cannot, without a personal inspection, throw any light on the exact names of the villages concerned, but I should imagine that Deota Malla and Talla are merely laggas of some parent village. The main idea of the proposal was, however, the evacuation of the area in order to prevent further damage leading to further erosion. The proposal was, however, vetoed by you after consultation with the Commissioner, vide your demi-official no. 602/11-12, dated December 11, 1930. Thereafter G. O. no. 74/330 W-1926, dated March 3, 1931, was issued and there the matter rests.

It is difficult, without a careful consideration of the problem on the spot, to express any definite opinion on it. It seems to me, however, very doubtful if any remedial measures of any value are possible short of the total evacuation of the area in question, its closure to any form of user by villagers and its reafforestation. And there is the opinion expressed in the Government order—presumably based on the opinion of the expert engineers—that even drastic action of that sort might not affect the deeper movements. Anything short of that, however, would I think merely cause considerable discontent amongst the local people for nothing. Unless, therefore, Government is prepared to adopt the policy of compulsory evacuation, I think that the conclusion previously reached, viz. to let nature take its course, is the only possible one. In view of all the circumstances of the case I am personally inclined to think that it was the right one.

V. A. HERBERT,

Conservator of Forest, Kumaun Circle.

Copy of a memo. no. 343/XXXV—10, dated the 10th August, 1937, from the Divisional Forest Officer, Naini Tal Division, to the Conservator of Forests, Kumaun Circle, United Provinces.

REFERENCE your no. 2895/XXXV—3, dated the 29th June, 1937.

In this connexion I would again invite your attention to this office letter no. 1891/XXXV—1, dated February 4, 1930, to you in which Mr. Haq has dealt with this matter.

Copy sent
ment with O
vator of For
no. 1428/11 -
14, 1930.

(1) *Charta Hill*—This contains partly reserved forest and partly *map* land belonging to Thokdar Beluakhan.

In the reserved forest adjoining the Charta slip there are some trees but the main trouble is that they are heavily lopped by the villagers residing in Charta chak and neighbouring villages. The residents are mostly *airtan assamis* of the Thokdar Beluakhan who are the worst offenders. Therefore, unless some steps are taken to remove them, any protection work, which is taken in hand by planting trees in blank places and closing the whole area including the slipped one for grazing by a suitable fencing, will be useless. The Government are not of opinion to do so. The slipped areas have been shown in red in the attached tracing and the lopped area in yellow. If we close this area for grazing there will be an outcry from the villagers and the fencing will not be successful there being no other place nearby where these *assamis* could conveniently graze their cattle.

(2) *Manora Hill*—The slip in Manora Hill is situated within the municipal boundary and the only solution is to close the whole area by wire-fencing with restriction against quarrying stones, removal of bajri, grazing, etc. After doing this some shrubs may be grown in the accessible portions and these, in course of time, will cover other portions naturally.

It was my intention to inspect these areas myself and then submit a report. But, being indisposed, I have been unable to do so. In view of the urgency mentioned in your reminder no. 1/226, dated the 7th August, 1937, I have no other alternative but to submit the report as it is.

(3) With reference to your no. 226/XXXV—3, dated July 27, 1937, I desire to report that no planting work has been done in compartments 27 and 28 during the current rains.

Name of patti	Names of villages having rights	Number of houses	Population	Number of families	Number of ploughs	Number of cattle admitted to free grazing	Timber for building in the log per annum		Wood for agricultural implements (cubic feet in the log per annum)	Firewood from fallen wood (in loads per annum)	Charcoal for blacksmiths (in loads per annum)	Miscellaneous underwood	Fodder grass	Fodder grass for sale	Grass for thatching	Babar	*Green leaves for fodder	Dry leaves	Fruits and roots	Bark of creepers	Bamboo (in score per annum)	Stone for buildings	States	Limestone	Irrigation channels	Water for mills	Fishing	Burning Ghats	
							Dwelling houses (chir or sat)	Cattle sheds (Miscellaneous wood)																					
Pahar Chhakhta	3	4	1	5	5	45	4	400	..	O	R	R	R	O	R	R	R	4	R	R	Maliya Boira and Nalena nadi.	Baliya and Nalena.	Bagarkot
	Manora	..	..	3	1	5	..	50	4	300	..	C	R	R	R	R	O	R	R	R	3	R	Do. ..	..	..	Do. ..	Do.
	Naikans	..	..	3	3	16	..	60	6	600	..	O	R	R	R	R	O	R	R	R	6	R	Maliya and Bhira.	..	..	Do. ..	Do.
	Balul Khan	..	800	6	3	16	..	60	6	600	..	O	R	R	R	R	R	O	R	R	R	6	R	Do.	Do. ..	Nalena river and Bagarkot	
Balul Khan	..	14	1,408	49	13	71	400	550	26	4,900	120	C	R	R	R	R	O	R	R	R	49	R	Do. ..	..	..	Baliya nadi.	Do.
Charkas	..	1	..	9	3	16	50	110	6	900	..	C	R	R	R	R	O	R	R	R	9	R	Do. ..	..	..	Do. ..	Do.

* Green leaves are only allowed when there is a fodder famine.

NOTE—There is not so much damage on account of rights as is from illicit lopping.

Public Works Department, United
Provinces,
Buildings & Road Branch.

No. 377 C/3397-1926, dated Lucknow December 17, 1929.

From

T. Sloan, Esquire, I.C.S., M.L.C.,
Secretary to Government,

To,

The Chief Engineer, United Provinces,
Public Works Department,
Buildings and Roads Branch.

Subject.

Report on the hillsides of Naini Tal.

Sir,

I am directed to forward four copies of the report of the committee appointed to examine the stability of hillsides in and around Naini Tal together with 4 copies of the report by Mr. A. L. Coulson, Assistant Superintendent, Geological Survey of India, and to communicate the orders of the Governor acting with his Ministers on the questions arising out of the report which concern the Public Works Department. The references below to the various items (a) to (e) and to the numbers under item (b) are to the items and numbers as given in the report:-

Item (a). Maintenance of existing protective works

The recommendations of the committee are accepted

viz.

- (a) that all drains constructed in the future should be made of ample capacity,
- (b) that estimates relating to new drains or alterations to the existing drains should not be destroyed and that for ~~the~~ subsequent reference all works in connexion with the drains in the Naini Tal Basin should be recorded under one main head; and
- (c) that the list of drains for the period 1907 to date be completed on the lines of the list prepared in 1907.

As regards the cases of individual drains, specified by name, considered by the Committee, Government understand that the Public Works Department have already taken action and for that reason no specific orders of Government are necessary. Government, however, request you to note for future guidance the action suggested by the Committee in cases of unauthorised interference with drains.

Item (b). Need for further protective works.

The orders of Government on proposals (1), (2) and (3) will be found later under item (j).

Proposal 4.

Proposal 13. - Stoppage of the leakage of the lake under Wargrave house and the Chase.

As the leakage from the lake is a grave matter, Government consider that the source of the leakage should be further investigated and a report submitted in due course.

Items (14) and (15). Afforestation of the slipped areas of Menora and Cherta Hills.

These two hills are outside the area of the lake basin and the question of afforestation is being referred to the Chief Conservator of Forests.

Item (c). - Observation stations and need for additional stations.

Government accept the recommendations of the Committee and understand that action is already being taken to give effect to them.

Item (d). - Lake regulation and authority for control of the same.

Government agree with the Committee that the control and regulation of the lake overflow should remain in the charge of the Public Works Department. The acceptance of the further recommendations regarding the lake-gauge and clock-work recorder will depend on the expenditure involved. Government understand that you are having estimates prepared or will report further on the proposals when the estimates are ready.

Item (e). - Authority for excavation, building and tree cutting.

Government are dealing with this item in the municipal department.

Item (f). - Rainfall run-off, assessment of normal leakages and evaporation, and fixation of a reasonable figure for run-off.

The recommendations of the Committee are of a very technical nature. Government understand that they are receiving your attention and that you propose to issue instructions based on them.

Item (g).

Item (g). - Verification of the catchment area and whether the Sukha Tal area should be included or not.

The Government accept the recommendation of the Committee that the catchment area should be verified and understand that this is already being done. In regard to the inclusion of the Sukha Tal area in that area and the drainage of Sukha Tal they propose to defer orders as they understand that the Superintending Engineer, Public Health Department, is opposed to the recommendations of the Committee. I am to ask that you will obtain a report stating the grounds on which this opposition is based and submit it for the consideration of Government.

Item (h). - Method of calculation of discharges.

The recommendations of the Committee should be examined and a report submitted in due course.

Item (i). - Method of recording rain gauge readings.

Government accept the recommendations of the Committee. It seems advisable to locate rain gauges at old and new Government Houses in order to compare the average of these gauges and that at the Public Works Department godown with that of the Secretariat.

Item (j). - Removal of the large rock above the East Laggan road and near Killarney House.

Government accept the recommendations of the Committee regarding the East Laggan and Hermitage roads and as steps are being taken to give effect to these recommendations no orders of Government are required. As regards the rock on the Almora (Kalakhan) road, Government are of opinion that as the removal of this rock will be expensive and as it has no connexion with the safety of Naini Tal, its removal is not an urgent necessity.

Item (1) - Periodical inspection of drains etc.

Government accept the recommendations of the Committee. Necessary steps should be taken to ensure systematic inspection.

Item(1)(i) - Examination of Charta Hill.

The present arrangements are satisfactory and should continue.

Item(1)(ii)- Examination of Amparao.

The result of the protective measures already taken should ^{be} watched. As regards the question of a diversion Government are of opinion that as the possible alternative routes also include unstable areas it is advisable to retain the present route pending the result of the protective measures already taken.

Item(1)(iii).- Reconstitution of Kumaon Division.

Government would prefer to postpone the consideration of this recommendation for the present in view of the fact that two assistant engineers are already attached to Naini Tal and the question is not one requiring immediate consideration.

I have the honour to be,

Sir,

Your most obedient servant,

Sd. A.R. Burns,

Assistant Secretary,

For Secretary.

Enclosure.

Eight copies of reports.

From- G.L.VIVIAN, Esq., I.C.S. DEPUTY COMMISSIONER,
Maini Tal, and PRESIDENT, HILLSIDES COMMITTEE,

To- The COMMISSIONER,
Kumaon Division, Maini Tal.

Dated Maini Tal, September 24, 1928.

Sir,

I have the honour to submit the report of the Committee appointed by G.O.no. 163-C, dated September 6, 1927, to examine the stability of the hillsides in and around Maini Tal the terms of reference being:-

- (a) Maintenance of existing protective works.
- (b) Need for further protective works.
- (c) Observation station-

- (1) Existing.
- (2) Need for additional stations.

- (d) Lake regulation and authority for control of the same.
- (e) Authority for excavation, building and tree cutting
- (f) Rainfall run-off, assessment of normal leakage and evaporation.
- (g) Verification of catchment area and whether the Sukha Tal area should be included or not.
- (h) Method of calculation of discharges and fixation of a reasonable figure for run-off.
- (i) Method of recording rain gauge readings.
- (j) Removal of the large rock above the East Lagga road and near Killarney house.
- (k) Periodical inspection of drains.
- (l) Examination of Cherta Hill and Amparao.

2. The Committee originally consisted of the following members:-

- Mr. W.T.S. Dobbs, I.C.S., Deputy Commissioner of Maini Tal.
- Mr. L.B. Spilsbury, I.E.E., Deputy Chief Engineer, 2nd circle, Provincial Works.
- Mr. J.D. Tunnicliffe, I.C., Officiating Superintending Engineer, Public Health Department.
- Mr. T.M. Lyle, I.E.E., Executive Engineer, Headworks division, Garo Canal.
- Mr. C.G. Edgar, I.E.E., Executive Engineer, Kumaon Division.
- Mr. A.C. Coulson, Assistant Superintendent, Geological Survey of India.

Mr. Dobbs was President of the meetings held in Maini Tal, but on his transfer to Rudauli as Magistrate and Collector he resigned in favour of Mr. J.M. Clay, C.I.E., C.B.E., I.C.S., Deputy Commissioner of Maini Tal.

My contribution to the work has been only to check and forward the report. For the summary of the Committee's recommendations on items (f) and (h) I am indebted to Mr. R.H. Hood, I.E.E. The rest of the report was drafted by Mr. J.V. Mineville, Superintendent, Public Works Department, who acted as Secretary to the Committee.

3. The Committee though it actually met three times only, devoted much time to inspection and its recommendations are recorded after careful consideration of each of the terms of reference.

These recommendations are as follows:-

Item (a).- Maintenance of existing protective works.

The question discussed under this term of reference covered an examination of the existing protective works and whether their maintenance had been effective or not. The attention of the Committee was at the outset invited to the following note by Mr. S. G. Edgar, Executive Engineer, Kumaon Division, in the annual report on the hill slopes round Naini Tal for the year 1925.

"The low figures of percentage discharge.- At the time of writing I am of opinion that errors may exist in the percentage of previous years and though I have attempted to check these I have not been able to do so due to the state of office records consequent upon the abolition of the district engineer's office. I do not consider the percentage discharge for 1925 as given in the foregoing report as being of unassailable accuracy for various reasons, but while these need further investigation their application to the present figure might vitiate comparison. In any case I do not regard the low percentage with complaisance. I consider that it indicates the need for greater vigilance with regard to the state of the masonry drains in the lake basin and I am taking steps in this connexion. It may indicate the need for reversion to what I might call old time methods, but I would prefer to await the oncoming monsoon and delve into matters of ancient history before I make definite recommendations.

"In the history of the settlement there have been occasions when garden terraces have been sloped off, tennis courts in certain localities have been rendered impervious by clay covering; gutters to all houses in certain areas have been insisted upon and at one time there was a four acre minimum area assigned to a bungalow compound. Most of these methods are now not attended to and I believe some have been set aside officially.

"The trend of the times is undoubtedly to ignore the recommendations of the older generation of engineers, geologists, and others who made Naini Tal the popular hill resort it is, but taking last year's percentage discharge as accurate for the purpose of argument it seems to me for the short experience I have had of the division that matters have gone far enough. The percentage discharge is in my opinion the index figure of the safety of the settlement and even while questioning its accuracy I would regard any further decrease as of ominous portent.

I am endeavouring to trace the history of resolutions and orders governing the problem, and taking steps to ensure careful attention to detail and will attempt to remove all existing inaccuracies in the calculation of this most important figure. Meanwhile I do not see that more can be done."

In this connexion the drains on the Sher-ka-danda dangerous area were inspected during the rain which fell in September, 1927. It was found that with prolonged quiet rain of no great intensity practically no water was discharged into the drains even after a fall of an hour. This is not the fault of the drains but is to be attributed to extensive absorbing capacity of water of the shales and slates and to the degree with which the grass and tree-covered soil cap retains moisture and offers ready access for the water in preference to allowing it to run off into the drains provided for the purpose. Such being the case one cannot but expect a small percentage run-off for light rain. With heavy rain, however, the drains get ample opportunity to demonstrate their utility.

The Committee is of opinion that the existing protective works that are under the charge of the Public Works Department are adequately maintained and serve the purpose for which they were constructed. It was brought to notice that in some cases the capacity of the drains is insufficient at times of heavy rainfall. It could not be ascertained which specific drains came under this category and the Committee therefore hold that

each should be considered on its merits and the drain concerned either enlarged or supplemented. The Committee is also of opinion that all drains constructed in the future should be made of ample capacity.

Individual cases were specially considered by the Committee

Drain no. 26 needs regrading where it crosses the Upper Cheena Mall above Balmoral and Melrose to prevent choking at the road crossing. It was understood that an estimate had been prepared for this work and was awaiting funds from the municipal board. In cases of this kind where the safety of the hillside is concerned the Committee is of opinion that the municipal board should find money without delay.

The ditches above ~~Seva~~ Oak Park and the junction of Tonochy road with the Upper Cheena Mall, which had been constructed for the trapping of debris falling from Cheena should be kept sufficiently clean to permit of free drainage into the drains provided in the area.

The drainage of Durgapur spur was not only inadequate in itself but such that there is, is neglected and consequently inefficient. These drains should be kept clean and in repair.

The Committee is of opinion that efforts should be made to complete the list of drains for the period 1907 ~~and~~ to date on the lines of the list prepared in 1907.

The Committee is also of opinion that in order to have a complete record of protective works undertaken estimates relating to new drains or alterations to existing drains should not be destroyed and it is also suggested that for subsequent reference all work in connexion with drains in the Naini Tal basin be recorded under ~~an~~ one main heading.

Finally the Committee considered the question of the unauthorized interference with drains. A concrete case was brought to the notice of the Committee and while it agreed that no action should be taken on that case, it suggested that in future cases an application should be made to the Magistrate in first place for an order under section 133 of the Code of Criminal Procedure on the ground that there has been an "unlawful obstruction or nuisance in a public place". The explanation to the section shows that the term "public place" includes State property and any ~~and~~ action by a private individual which causes damage or danger to the public would certainly be a nuisance. In case the application is refused or in any case if damages are claimed an application might be made to the civil court in the form of a suit for damages together with a request for a temporary injunction under order 39 of the Code of Civil Procedure.

A list of drains which was prepared for the Committee by the Executive Engineer, Kumaon Division, is appended to this report.

Item (b) .- Need for further protective works.

Proposals for further protective works were then considered by the Committee and it was decided to recommend the following for the favourable consideration of the Government :-

- (1) Removal of the two large rocks above ¹⁶East Lagan road.
- (2) Removal of the dolomite block on the Hermitage road.
- (3) Removal of the rock near pillar B-1 (Maimukhet), threatening the Banikhet road.

- (5) Provision of adequate drains and revetment walls after the fall of the threatened area below the old reserve Police Lines.
- (6) After the fall mentioned in (5) the control of the Ballia from Fairy Hall drain to at least its junction with the Mota Pani stream at Durgapur.
- (7) Provision of adequate drainage, etc., on the subsiding area of the Depot road.
- (8) Provision of adequate drainage on the threatened area in the vicinity of pillars nos A-1, A-2, B-2, C-2 and D-2 on Kalakhan Hill and the prohibition of cultivation in that region.
- (9) Total demolition of Durga Cottage and the sloping off of this area followed by afforestation.
- (10) Possible sloping-off of the tennis court at Fairlight Hall or the provision of a rammed clay foundation if not already existent.
- (11) Provision of adequate drainage above Maldon Cottage with the possible sloping-off of the vegetable garden of St. Cloud Cottage.
- (12) Drainage of Sukha Tal.
- (13) Stoppage of the leakage of the lake under Wargrave house and the Chase.
- (14) Afforestation of the slipped area of Manora Hill.
- (15) Ditto area of Charta Hill.

Items (1), (2) and (3) have been dealt with separately by the Committee.

As regards items (5) and (6) the Committee would suggest that the lower reaches of the Ballia should be treated progressively in an attempt to bolster up this area. Several bedbars should be built every year and linked up as funds permit. This should be an accepted policy and if time does elapse between the construction of the bedbars and their linking up with the lined drain, the bedbars should be kept in repair.

In connexion with item (9) the attention of the Committee was drawn to the condition of the area between Edwinstowe and Glenlee on Ayarpatta. The Committee came to the conclusion that the old garden and mass of vegetation below Glenlee and the stables attached thereto might be cleared and grass planted, as at present water can readily enter the soil cap above a distinctly dangerous area. The tennis court in Glenlee should have a rammed clay foundation if it does not possess one already. It was pointed out to the Committee that the rocks in the vicinity of Durga Cottage have their maximum dips practically in the direction of slope and their dip is less than the angle of slope-conditions which are exceedingly favourable for a slip. With regards to Galloway House and the garden below, the Committee do not consider the area as being as dangerous as that of Durga Cottage, but it recommends that further excavation in that area for construction should be prohibited. The garden should be sloped off to a slight extent. It is not imperative that it should be entirely sloped off. This action can be taken when indications point to the area becoming more dangerous. The Committee advise the erection of observation pillars on the Glenlee, Encliffe and Galloway House spurs and the record of the annual movements of these in the report on the hillsides of Naini Tal prepared by the Executive Engineer, Kumaon Division. The erection of further buildings in the whole of this area, should be prohibited.

As regards item (12) the Committee invite attention to the report by Mr. Coulson on this subject. The Committee recommends this work provided it can be done cheaply. The question however is one which can best be dealt with by the Public Works Department.

Item (c).-Observation stations and need for additional stations.

The Committee examined the methods of obtaining and recording the readings of the movements of the hillsides and is of opinion that the present system is reasonably accurate and may continue. It must, however, be borne in mind that the value of the readings and observations is somewhat discounted by the fact that it is impossible to say definitely whether all the observation stations can be relied upon, that is it is not stationary from year to year. Unfortunately there is no means of overcoming this difficulty and the present system so far as we can see must remain; in fact the Committee would go a step further and recommend the erection of additional observation stations and pillars. The method of taking observations is in the opinion of the Committee sufficiently correct if the personal element involved can be absolutely relied upon. It is noticed that only one subordinate is delegated for this very important duty and there does not appear to be a sufficient check ~~xxxx~~ exercised over his work, for according to the book containing the readings, it appears that Mr. Hatfield, late District Engineer, was the last responsible officer who checked observations. The Committee consider it very important that every care should be exercised in recording these observations and measurements and would recommend -

- (a) that a responsible gazetted officer be placed in charge of all records and observations in connexion with the hillslopes;
- (b) that two subordinates should take the readings and sign the book maintained for the purpose;

Note.- It is not necessary that the subordinates should take the readings on different dates, it will be quite sufficient if they accompany one another and take the readings together.

- (c) that the gazetted officer in charge of hill slopes should check a definite percentage-say 25 percent.- of the readings and measurements each year;
- (d) that the Executive Engineer, Kumaon Division, should also check a percentage- say not less than 5 percent.- of all readings and measurements.

Distances of certain base lines required for the calculations of the movements were shown to the Committee on its inspection and the Committee were informed that these had been ascertained by Mr. Sinclair when he was District Engineer, Naini Tal. The Committee presume that these were taken by actual measurement on the ground and can be relied upon. However it would be as well if they were checked as a slight error would make an appreciable difference in calculated ~~xxxx~~ movements.

The Committee considered that the standing orders governing the taking of observations are not sufficiently definite and furthermore there appears to be no record of them in the Chief Engineer's office. It suggests therefore that in this case as well as in the case of operations on and inspections of drains and protective works, etc., standing orders covering a clear definition of each problem and specific duties be drawn up and copies recorded in the Chief Engineer's office. There should also be recorded printed drawings and forms, each drawing and form being comprehensively descriptive

of the subject dealt with. As regards observation stations the Committee consider that there should be a large scale map of each area showing the observation stations and pillars. On this map should be shown the original observations and calculation of distances with a reproduction of the standing orders governing the taking of observations. There should also be a register of observations in both the offices of the Divisional and Chief Engineer.

Need for further stations.- The Committee are of opinion that pillars should be erected upon the spur of Kaimukhet above the Brewery bridge on the Bhowali side of the Ballia, their position to be determined by the location of the cracks which occurred in 1926. The existing pillar A-1, B-1 and C-1 record movements higher up this hill in a region which is at present safe (they lie outside the cracked area of the hill). Before the threatened slip in the vicinity of pillars A-2, B-2, C-2 and D-2 takes place it is likely that premonitory symptoms will be indicated in the lower spur under discussion. Such being the case, the study of the movements of pillars erected on the lower spur above the Brewery bridge would be of great assistance.

The Committee consider that the area below the old reserve police lines is an exceedingly dangerous one and that every care should be taken to give adequate warning of an impending slip. Pillars should be erected on the soil covering of the spur, at the edge of the cliff and further inland, and observations taken from the Bleak house station, if possible. The Committee are also of opinion that the Gangipur spur is another area that might well be observed. In this case though conditions tend towards stability with the rocks dipping into the spur, ~~xxxxxxxxxxxxxx~~ the Ballia stream is at present uncontrolled at the foot of the spur and so is free to commence its work of destruction. The installation of additional pillars higher up Charts Hill is recommended. Even with the fall of the areas near pillars nos. 1 and 2 this hill will not reach stable conditions and it is as well to be prepared for possible catastrophes. The Committee also recommend that the spur between the slip of 1924 and the Durgapur stream running down from Manora be watched, specially in its lower regions. With the cultivation at present allowed higher up this spur, free access is given for water to enter it. Finally the Committee recommend the erection of observation pillars on the Metiali and Amparo areas and also a pillar on The Springfield spur as being of great value.

(Item)(d) -- Lake regulation and authority for control of the same.

It was brought to the notice of the Committee that the original rules for the regulation of the overflow of the lake were issued in the year 1399 under the signature of the then Executive Engineer of the Kumaon division and these rules ~~continued~~ continued to have force until the installation of the hydro-electric scheme, when it passed into the hands of the municipal board. On a representation being made by the Executive Engineer the control of the sluices was retransferred to that officer with the approval of the Electrical and Mechanical Engineer of the municipal board. The Committee read the records placed before it and decided that the lake control and regulation should remain in the hands of the Public Works Department and ~~form~~ form one of the duties of the Executive Engineer, Kumaon division. Observations should be taken all the year round and complete records for the full year published in the annual report on hillslopes. The Committee is of opinion that the lake gauge is not very ~~at~~ satisfactory as it is not high enough to record the higher gauges when water escapes over the road at Talli Tal, and ~~it~~ considers that it would be better to erect a new gauge just above the new sluices. The Committee also recommend that a clock-work gauge recorder be installed to record the level of the lake on weekly charts. Graphs should be drawn up showing the rate of

discharge through the sluices for each half inch increase in lake level; this will simplify the maintenance of the records. The Committee understand that the post of District Engineer, Naini Tal, has been abolished and therefore it suggests that the standing orders for lake regulation be amended and a gazetted officer of the standing of an Assistant Engineer working under the order of the Executive Engineer placed in charge of all the lake records. This officer should, in the opinion of the Committee, also be made responsible for the observations in connexion with the movements of the hillslopes. It appears to the Committee that it would be wise plan to consolidate all the orders pertaining to lake regulation and observations and records taken in connexion with the hillslopes. These orders should then be submitted to competent authority for approval and thereafter printed.

In view of the fact that the municipal board is an interested party in the regulation of the lake, because it uses the water from the lake for power purposes, its wishes in the matter should be considered. The Committee accordingly recommend that the Electrical Engineer in charge of the board's hydro-electric works be consulted from time to time and his wishes complied with if compatible with safety. Finally, as a considerable amount of water is taken from the lake during the dry months of the year for the hydro-electric works the Committee consider it important that the water level of the lake be kept as high as possible at the end of September and beginning of October even at the risk of flooding a few inches of certain of the roads and the Naina Devi temple platform.

Item (e).- Authority for excavation, building and tree cutting.

The subject matter of this reference is largely responsible for the constitution of this Committee. The Executive Engineer, Kumaon division, has clearly explained his reasons for investigation of this matter in his letter no. 7546, dated August 18, 1926, to the address of the Chief Engineer, Public Works Department, Buildings and Roads Branch. That letter and its enclosures has been printed as an appendix to this report.

The Committee have very carefully considered this question and they have come to the conclusion that the present position whereby the authority for excavation, removal of soil, quarrying, erection, re-erection of houses, etc., is vested in the municipal board appears to be very unsatisfactory.

The Executive Engineer, Kumaon division, as an official member of the municipal board and an elected Chairman of the Public Works Committee is in a very invidious position, for if his advice on matters pertaining to excavation, building etc., is in accord with the wishes of the majority of the board it is acted upon; otherwise, in a good many cases, it is ignored.

Mr. Edgar, the present Executive Engineer, cites several cases where his advice on these matters has not been accepted with the result that disasters have occurred which could have been avoided.

The present rules and regulations vesting full powers in the municipal board should therefore be amended and the dual control, if it can be called such, brought to an end and the duties and powers of the Executive Engineer in regard to these matters strictly defined.

It is, therefore, recommended that the rule set out below, in force some years ago, vide G.O. no. 614/XI-159R, dated February 20, 1913, should again be enforced.

Rule 3.- The municipal board, Naini Tal, shall not sanction the erection or re-erection of any building or excavation, removal of soil or quarrying within the limits of the Municipality unless and until the Executive Engineer shall have certified that such erection or re-erection or such excavation, removal of soil or quarrying is not in his opinion likely to affect the stability of the hillsides.

The enforcement of this rule is likely to cause some delay in dealing with applications, and to avoid this it is recommended in the first place that all applications and plans should be sent direct to the municipal board and then submitted to the Executive Engineer by the Secretary for an opinion before they are placed before the Public Works Committee. If the Executive Engineer vetoes the applications he will return them to the Secretary with his reasons for non-acceptance; the papers then be returned direct to the applicant and the matter will not go before the Public Works Committee. There should be no appeal against the Executive Engineer's decision.

We strongly recommend that the 4-acre rule, which was passed by Government in 1902 under section 187 of the Municipal Act of 1900, and rescinded in 1920, should be again brought into operation. This rule reads:-

Rules under section 187, sub-section(1), clause(ss) of Act V of 1901 for prescribing a minimum area for building sites and a minimum distance between buildings in the Naini Tal municipality.

1. - Save as provided in rule 3, no building shall be erected outside the native bazar, on any site the area of which is less than four acres in a ring-fence.

2.- Save as provided in rule 3, no building shall be erected or re-erected, outside the native bazar, in such a manner that any portion of it would be less than fifty yards from any other building, provided that nothing in this rule shall apply to-

- (i) bona fide repairs to an existing building; and
- (ii) a building intended as an outhouse as regards any building to which it is intended to be attached, or as regards any other outhouse.

3.- Nothing in the preceding rules shall apply to a building erected and used-

- (a) exclusively for purposes of public worship;
- (b) as the house of the care-taker attached to a building used exclusively for the purpose of public worship;
- (c) for purposes other than residential or the keeping of animals;
- (d) for a European shop built in a continuous line of such shops on a road frontage.

The Committee also considered the question of the denuded areas in the catchment area of the lake. This question was originally considered by the Chairman, municipal board, in October, 1925. He brought to notice the fact that about 3,000 trees were felled between the years 1920 to 1925 in the lake catchment area, a fact which had left its mark not only on the denuded hillside, but also on the returns of fuel consumption at the depots, which returns showed a falling off of 30 per cent. during the period. As a result an officer of the Forest department was deputed to make a survey of the area and to suggest remedies. The report of that officer, which is printed as an appendix to this report, was considered by a sub-committee of the municipal board and the recommendations made by the forest officer were accepted with slight modifications. The recommendations accepted by the sub-committee are also appended to this report.

The Committee is of opinion that healthy trees should not be felled if they do not exert any leverage on the ground. Only those trees which are unsafe and have a tendency to disturb the sub-soil during heavy gales should be removed. The Committee consider that the recommendations of the forest officer referred to above seem reasonable and it suggests that they be enforced.

With regard to the authority for tree-felling the Committee presume that the authority is vested in the municipal board but as the question is one of importance and as the Committee have already recommended that the Executive Engineer of the Kumaon division be vested with complete authority to deal with cases connected with execution, removal of soil, quarrying, erection and re-erection of houses, etc; it strongly urges that the authority to sanction tree-felling be also vested in the Executive Engineer Kumaon division and that there should be no appeal against his decision. Finally the Committee is of opinion that the attention of the working-plans officer of the municipal forests be directed to the recommendations made by the Committee of 1907 in part 12, page 21 of their report.

Item (f).-- Rainfall run-off, assessment of normal leakages and evaporation, and fixation of a reasonable figure for run-off.

As the Committee largely owes its inception to the apparent falling-off in the percentage "run-off" given in the annual report on the hill-sides, they realize that it is one of their most important duties to state what they regard as a satisfactory figure for the future, a figure to be aimed at and secured if possible. The method of recording sluice openings, gauge readings and calculation of the discharges through the sluices and over the weir at Talli Tal will be gone under item (h) of the terms of reference. Under this head they consider that the method of arriving at the rainfall "run-off" followed in the past has not been altogether satisfactory and has given a somewhat alarming view of the present conditions.

Primarily, the Committee is of opinion that the area of catchment should be carefully verified as also the surface area of the lake, and that the figure so arrived at should be the basis of the annual calculations in future. It noticed that in the method of calculation of percentage "run-off" in the annual report by the Executive Engineer, quantities of water taken from the lake, as also quantities which naturally escaped from the lake, on account of the following items, had not been taken into account. (a) Town's supply taken from the springs in the catchment area of the lake itself, (b) unfiltered water supply to Government House and (c) on occasions of intense rainfall, unmeasured quantities of water from the lake overflowing the roadway near the post office at Talli Tal into the Bellia ravine, (d) loss by evaporation from the surface of the lake.

The Committee considers that there should be no difficulty in obtaining figures, each year, of the quantity of water taken from the catchment area for the municipal supply and of the quantity of water pumped from the lake for the unfiltered supply of Government House and recommend that the Naini Tal municipal board be asked to supply these figures to the Executive Engineer each month so that they can be taken into account for the annual calculation of the percentage, in the same way as quantities utilized by the hydro-electric works had been accounted for in the past years.

It considers that the absorption losses in the lake are of very great account and that absorption and evaporation in years of average rainfall amount to somewhere in the region of 35 per cent. of the total rainfall. The Committee has given this figure after having analyzed from available information the conditions during the two years 1925 and 1926, from which the actual mean

"run-off" of the hillsides area for these two years works out at 68 percent. and 72 per cent. respectively, i.e., a mean of 70 per cent. of the total quantity of rainfall in that area and it recommends that the annual "run-off" should be invariably recorded as the correct percentage hillside "run-off" after allowing for 100 per cent. "run-off" from the lake surface and that, in a normal year, the deduction of a quantity of water due to a depth of 3 feet 4 inches over the lake surface should be taken as the quantity evaporated. It considers that it should be possible to obtain accurate daily records of the lake level and, at least, monthly measurement of the discharges of all springs discharging outside the lake area, and with similar recorded measurements of the discharges of all springs situated inside the lake catchment the total quantity absorbed by the lake itself can be arrived at. When this is done, more conclusive figures for lake absorption and evaporation will be available and it will be possible to state annually in years to come whether greater or less absorption in the lake itself is taking place.

If the annual statements are extracted on the above principle the Committee agree that the figure of 70 per cent. run-off from the hillsides arrived at by them is the true index figure which can be taken as a measure of the efficiency of the surface drains and therefore a measure of the general stability of the hillsides. This percentage will vary with the amount and nature of distribution of the rainfall, chiefly during the monsoon and with the intensity of the heavier periods of rainfall. It thinks that steps ought to be taken to compile accurate records of rainfall, overflow discharges, evaporation, monthly discharges of springs, etc., in order that each year a proper analysis of the figure which will represent the annual percentage "run off" from the hillsides may be arrived at.

Item (g). - Verification of the catchment area and whether the Sukha Tal area should be included or not.

The Committee was informed that the figure adopted in calculations for the area of the lake was 120.5 acres and the figure adopted for the area of the lake catchment was 1.90 square miles and it was understood that the verification of the catchment area was being done in the office of the Executive Engineer, Kumaon division. This figure when arrived at should be recorded for future reference.

In connexion with this verification the Committee went into the second part of the term of reference. It was pointed out to the Committee that several drains from Cheena Hill discharged into Sukha Tal, and the level of the tal at the time of inspection by the Committee was a clear indication of the amount of water which did not make its way direct to the lake. The question arose whether this water would ultimately find its way towards Maini Tal by seepage and a possible line of passage of the water was along the lake fault north of Barron's Hill and thence by Langdale and Fine View. The possibility of sink holes in the dolomite would give the water a different passage. Screens rising to a height of 6,670 feet at the Vicarage blocked the exit of Sukha Tal at that end. Mr. Grant, late Assistant Engineer of the Public Works Department, who had been in charge of works in Maini Tal for many years, in his evidence stated that up to the year 1903 Sukha Tal held water throughout the cold weather but in that year the Muhammedans made an excavation for burying their tazias and the water thereafter drained out through the crevices below this excavation. He added that he knew of no springs whence the water used to issue. In view of the report by Mr. Coulson the Committee is of opinion that Sukha Tal should be included in the Maini Tal catchment area.

The Committee is also of opinion that the retention of water in Sukha Tal is dangerous to certain houses in the vicinity, i.e. Ashdale, the Vicarage, Deodars, St. John's Church, Grassmere, the Metropole Hotel and houses below and that the question of the drainage of this tal into the lake should receive the consideration of the Government.

Item(b).-- Method of calculation of discharge.

The Committee desires to bring to notice that the existing method of measuring the quantity of water discharged from the lake at Talli Tal is most inaccurate, it being more of an approximation than anything else. The present gauge from which the discharge are computed is insufficiently long and fixed at a point where measurements cannot be accurately obtained and, moreover, the shape of the approach channel to the sluices is such that accurate results from gauge readings cannot be obtained. On an inspection of the sluices being made it was ascertained that these were in defective condition and that the sills were not even level, further vitiating the accuracy of any computation of the actual discharges from readings on the gauge fixed to the over-bridge. At the time the Committee inspected the sluices the installation of new and up-to-date mechanism was contemplated, and this has since been put in. But it is doubtful if this will help much in obtaining accurate measurements of the actual quantities which escape, as the restricted intake and shape of the channel leading to the sluices does not conform with the modern practice, and the same trouble regarding the measurement of quantities discharged is produced, two conditions having to be taken into account, namely, (1) water discharged through the sluices and (2) over the sill.

The Committee is strongly of opinion that the present method of arriving at the total quantities of water discharged from the lake are not sufficiently accurate, and that these methods should be abandoned in favour of a more modern system which will enable all the water which escapes, including seepage from the lake into the Bellia ravine, to be measured. It therefore recommends that an automatic recording gauge should be fixed and a weir built in the Bellia ravine at chainage 12 pointed out by Mr. Edgar during its inspections. If this proposal is adopted the personal element in the recording of the daily gauges and the inaccuracies in computing the discharges through the sluices and over the weir will be eliminated and figures which can be relied upon for the calculation of the annual percentage run-off the catchment will be given.

As an alternative, it recommends, if it is impossible to augment, for financial or other reasons, the discharging capacity of the existing sluices that a high level masonry escape having suitable measuring apparatus be constructed near the existing low portion of the roadway adjacent to the post office at Talli Tal so that, during period of intense rainfall and "run-off", the discharge from the lake can be measured with a greater degree of accuracy.

It also recommends that the existing gauge on the over-bridge be replaced by an automatic recording gauge situated at the point nearer the sluices where the adverse hydraulic properties of the existing approach channel can be reduced to a minimum and more accurate computation of the discharges obtained after the discharge formulae at present in use have been amended and proper forms and registers have been compiled. In face of the investigations it has carried out it is unanimously of opinion that it is extremely doubtful if the records for the period 1922-26 can be relied upon, and that the percentages given in the annual report of the Executive Engineer are more accurately described, under the existing conditions, as "percentage escaped" than as "percentage run-off."

Item(i).--Method of recording rain gauge readings.

The rainfall figures, which are used in the annual report on hill-slopes, are based on the rain gauge at the Public Works Department godown. The readings of the rain gauge at New Government House are also recorded but they are not used in the calculations for run-off.

The present rain gauge at the Public Works Department

godown is, in the opinion of the Committee, unsatisfactory for the following reasons:-

- (1) It has a capacity for only 3 inches rainfall
- (2) It is badly situated, being much too close to the godown.
- (3) The site is altogether outside the catchment area.

There is undoubtedly considerable variation of rainfall at different points in the catchment area, and the Committee think that the average of rain gauge readings taken at a number of points, more or less evenly distributed over the area, would give a more accurate record. The rain gauges should be placed in clear open spaces and at points where the records can be maintained easily and regularly by responsible officials. The Committee suggests that the mean of the rainfall readings at the following three sites should be taken as the official Mini Tal average rainfall:-

- A- New Government House.
- B- Old Government House.
- C- The Secretariat.

These appear to be very suitable sites and a responsible official is, the Committee understand, available at each site for keeping the records. Rain gauges already exist at sites A and C. Each rain gauge should be capable of holding a total rainfall of about 15 inches to 20 inches, and the Committee would recommend the float pattern rain gauge instead of the bottle type which is in use at the Public Works Department godown.

If, however, it is thought that the keeping of records at three stations is likely to introduce many possible errors, then the Committee recommends that the gauge be maintained at the Secretariat alone and future calculations based upon the readings from this station.

Item(j).-- Removal of the large rock above the East Laggan road and near Killarney house.

The Committee had the privilege of receiving the expert advice of Dr. E.H. Pascoe, Director, Geological Survey of India. In the opinion of Dr. Pascoe, the rock called Craig Ellochie should be removed. Dr. Pascoe and the Committee consider that the rock, in its present cracked and overhanging condition, constitutes a grave menace to frequenters of the East Laggan road and the Lower Mall. Though the tell-tales inserted by the Public Works Department showed no movements, the fact was due to the cracks in which they were inserted being more or less horizontal in nature. Geological reasons for the removal of the Craig have been given in the past by other geological experts and need not therefore be amplified.

The Committee which was appointed in 1907 reported as follows:-

"As regards East Laggan the Committee have no remarks to make except that they consider that when the road from here to the flats is widened, the picturesque rock known as Craig Ellochie should not be touched; the road can be widened on the outside without any difficulty.

With a view to retaining this picturesque rock, an estimate by the Public Works Department, which provided for the clearance of all trees, bushes and all vegetation from the surface of the ground surrounding the rock and the filling up of all crevices and cracks with 6 inch thick facing cement concrete over lime concrete so that the rain water could not percolate through these crevices and cracks. A surface drain round this rock was also to be constructed to take all the surface water during the monsoon down the proper channel. The cost estimated is Rs. 8,472.

Dr. Pascoe, however, is of the opinion that the rock should be removed together with the large rock above it. He recommends that the work of removal be commenced from above, and that, on account of the possible danger of swamping by waves caused by the fall into the lake of large masses of rock, due precaution be taken to ensure that no one is on the lake at the time of the removal of the rocks in question. The Committee unanimously accept this opinion and recommend to Government that the rock be removed. It is difficult to say what the removal of this rock will cost, but it is possible that it will be considerably less than the underpinning and drainage provided for in the estimate referred to above.

Scaffolding will have to be erected and the rocks chipped away piecemeal. Blasting would be dangerous as not only might it shift the centre of gravity and cause an immediate collapse, but it might cause further disturbance in the vicinity. The hollow to the right of the rock should be filled in and topped with rammed clay.

Dr. Pascoe and the Committee also inspected a large mass of dolomite near the Hermitage and on account of the grave danger to part of the Metropole Hotel they ^{unanimous} in their opinion that it should be removed.

In the course of his inspection Mr. Coulson brought to notice the existence of a dangerous rock near observation pillar no. (B)(1) on the ~~at~~ Almora (Kalakhan) road. The Committee had not inspected the site but considers that the Public Works Department should look into the matter and report whether the rock should be removed.

Item (k).-- Periodical inspection of drains, etc.

The Committee was informed that ^{the} inspection of drains and protective works had hitherto been carried but in a more or less haphazard manner and it therefore considered it desirable that a definite system of inspection should be adopted. In the first place it is essential as already pointed out by the Committee in its report on item (a) of the terms of reference that the list of drains and protective works, which at present is complete only up to the year 1907, should be brought up to date as far as possible. It was brought to the notice of the Committee that certain works had been classed as "Special repairs" and as estimates for this class of work were destroyed after a certain length of time it might not be possible to make the list of completeness that could be guaranteed, though it was probable that only works of minor importance would escape omission. In this connexion it is essential that in future all estimates pertaining to drains and protective works, be they (repair' or 'original' construction, be recorded under one general heading and carefully filed for future reference. Registers of each area should be maintained in the Divisional and Chief Engineers' offices and each work entered in the register immediately it has been carried out.

Mr. Edgar, Executive Engineer, Kumaon division, stated that he had been considering the institution of a definite system of inspection and to this end had divided up the Nainital basin into three main areas and had prepared a plan of each area on which he had posted a list of the drains, roads and protective works in that area. He had further divided inspection into four parts:-

- (i) Inspection of drains,
- (ii) Do. roads,
- (iii) Do. other protective works,
- (iv) Do. observation stations,

and had drawn up inspection forms for the above.

These forms were scrutinized and the Committee considers

That they meet the needs of the situation ^{and} adequately as possible and recommends that they be standardized and their regular use insisted upon. This system will ensure inspection of every known drain, road, other protective work and observation station in the Naini Tal area three times a year by the subordinate in charge, twice a year by the Assistant Engineer and once a year by the Executive Engineer. The Committee considers these inspections the minimum consistent with safety.

Item(1)(1).- Examination of Cherta Hill.

Mr. Coulson has gone into the geological aspect of this problem and the Committee would invite attention to his report. From that report it is clear that the lines on which the Public Works Department are working at present are the best that can be adopted. There is consequently little for the Committee to say on the subject as the actual details of the work proposed to be done remain to be settled by the department and therefore do not come within the scope of this Committee. Broadly speaking, the work proposed is to straighten up and reduce the slope, so far as possible, of the main channel above the road bridge. In regard to the lower portion of this main channel which was badly damaged by the heavy rain in August, 1927, it is obviously necessary to straighten it out so as to give the torrent a straight run and to build a series of falls as heavily protected as possible. It may further prove desirable to widen the bridge and lower the floor of the drain beneath ~~it~~ it, but this question will no doubt be considered by the department.

Item(1)(2).- Examination of Amparao.

In dealing with this term of reference the Committee was faced with a very complex problem. In order to understand the material facts and arrive at a decision the Committee divided the problem into three parts, viz:-

- (a) Criticism of work done up to date.
- (b) Consideration of the steps to be adopted in the future.
- (c) Whether it is advisable to vacate the area if the construction of a road elsewhere is feasible.

In connexion with the first part it was made clear to the Committee that the Amparao area consisted of three sections. Commencing from the Kathgadom end there is a loop of road which in the year 1927 settled three feet. In 1918, this section gave trouble but the trouble to a large extent was remedied by the construction of a wall-known as the Verriers wall which was built in the gale below the road and which contributed largely to the reduction in the amount of settlement. Apart from the construction of the wall, the water which flowed down the gale was diverted and the culvert on the road blocked up. By this means and others the gale was rendered as dry as possible. The next area which gives trouble is that above which there is a slip. Here the road settled some 35 feet in 1927. A wall was also built at this site but during the rains of 1926, it was outflanked at the Naini Tal end. Repairs were effected in the cold weather of 1926-27, but the wall was again damaged during the rains of 1927. The gale at the foot of which the wall has been built carries a large amount of water, which comes partly from the gale previously referred to and partly from a stream which flows through a village above the road called Dangar. The Executive Engineer of the Kumaon division is of the opinion that the subsidences which occur at Amparao in the two sections referred to and in the one still remaining to be mentioned and also in the Metiali area lower down the road have one common origin. Above the village of Dangar is a range of high hills. These are steep and appear to be composed of fairly bare sloping sandstone. The slope of

these rocks is so steep that water falling on them rapidly discharges in its entirety. This water finds its way towards the card road but before it reaches the road it traverses a flattish area of land. In this flattish area it is understood rice cultivation is carried on and that during certain months the fields are flooded by irrigation. It would appear, therefore, that the holding up of water in this area has a bearing on the cause of the subsidences. Percolation from ~~the~~ these cultivated fields provides a reason for the existence of springs in the face of the slip. An attempt was made to obtain information by digging pits through the slip material. The evidence obtained was not in all cases conclusive but it was felt that the depth of the slip material had been gauged. Two drains were accordingly constructed, one ~~xx~~ slightly above the road and the other higher up the hillside. These drains while having sufficient bed slope were roughly 25 feet below the surface. As far as possible they were kept in contact with material which did not appear to have slipped. They consisted of a masonry invert covered with a thin layer of cement concrete, had side walls and were roofed with reinforced concrete slabs laid with spaces between them. Above the concrete slabs boulder filling was introduced and on the top of the boulder filling clay puddle was laid. Roughly speaking these drains were about 300 feet long. From the surface down into the drain were vertical shafts and it was arranged that ~~xxxxxx~~ most of the surface water should have access to the tunnel below by means of these shafts. The drains were completed in June, 1927, and up to August 24, of that year it seemed that they were effective. On August 25, however, the road commenced to subside and moved down about 35 feet in one night. This movement was accompanied by a forward movement of earth towards the big wall below, which changed the contour of the slip above from concave to convex. The position of the slip and the direction of the movement caused the earth to move towards the nals in this bay as well as down towards the wall. Water coming down the nala now runs along the top of the earth which moved and as this nala is not lined it is probable that its presence in an unlined drain has a distinct bearing on the case. It seems necessary to consider whether it is a mere matter of time before the present slip settles down, if so, whether when it has settled down stability will have been reached or further slips will occur. Further up towards Mini Tal but still in the Amparo area is the third area of slip. Here again a section of the road subsides year after year despite the building of two wells down below. In connexion with the geological aspect of the Amparo area the Committee cannot do better than refer to the detailed report by Mr. Coulson, pages 19 to 22. The Committee is of opinion that normal methods of draining the debris of the slip can never be successful. The experience gained from the "adits" proves this. These adits never carried any amount of sub-soil water and when there was a reasonable discharge it was surface water which obtained access to the tunnels down the vertical shafts. The Committee recommends that the work on the slip should be confined to and consist of (1) sloping of the surface above and below the road as to permit of quick surface discharge and (2) the planting of trees and grass. As regards the construction of a road elsewhere the committee considered three proposals:-

- (1) Higher up the slipped area.
- (2) Behind the hill 3,300 feet.
- (3) Across the Nalena river.

The first was discounted by the fact that the geological structure of the hillside did not permit of a safe foundation for the road and the amount of excavation necessary would render the hillside more unstable than before and so accentuate the present trouble.

The second also was not acceptable because it would be necessary to add to the length of the road by two miles, the cost of which would be prohibitive. The third presents the same geological difficulties that exist at the present site of the road except that the spring is absent, and the Committee came

to the conclusion that the conditions across the Malena are not sufficiently favourable to warrant the abandonment of the present road which should be maintained at least until the suggestions made above have been tried and found unavailing.

Reconstitution of the Kumaon division.

The question of the reconstitution of the Kumaon division is a corollary to the other recommendations of the Committee. It does not form one part of any of the terms of reference but taking into consideration the fact that if the various recommendations of the Committee are accepted by Government, a considerable amount of additional work will be thrown on the Executive Engineer, the Committee is of opinion that the Kumaon division as constituted at present is more than one executive engineer can adequately cope with. It may be argued that the division has always been of the same size, that the work has recently been actually reduced by the handing over of certain local roads in the Almora district to the district board, that the work has been satisfactorily carried out in the past and that therefore no grounds exist for reconstituting the division. The reply to these arguments is that the investigations of the Committee and the fact that in most cases effect was not given to the recommendations of the Committee of 1907 prove convincingly that the work has not been satisfactorily carried out in the past and that the slight reduction of work consequent on the transfer of certain local roads has been more than counterbalanced by the great increase of work in connexion with the cart roads due to the heavy motor traffic they now have to carry. A very much higher standard of maintenance is expected now in the case of roads subject to heavy motor traffic than in the past when light bullock carts and tongas used the roads.

The Committee is of opinion that as matters are at present the Executive Engineer if he attempts to carry out his work in the manner in which it should be done, should make at least two tours in the Garhwal district every year. Each of these must involve his absence for some six to eight weeks, with the obvious result that he will be compelled to be out of direct touch with matters in Mini Tal for at least three or four months in any year. The Committee therefore suggests that the Executive Engineer, Kumaon division, be entirely relieved of the charge of Garhwal district. There are two possible ways of effecting this—

- (a) by re-opening the Dehra Dun division and including Garhwal in that division, and
- (b) by dividing the existing Kumaon division into two—east and west. The east division would be the more important of the two and would comprise Mini Tal and most of the Almora district. The west division would include Garhwal, possibly the Government House sub-division, the Batighat-Ranikhet section of the Bareilly-Mini Tal road and the Ramnagar-Ranikhet road. These sections of road will give the Executive Engineer, West division, direct access to Garhwal.

The first proposal poses two obvious disadvantages. First, the Executive Engineer, being stationed at Dehra Dun will not be in direct touch with the Commissioner of Kumaon. Second the transfer of subordinates will be inter-circle instead of being inter-direct.

In the former case the Commissioner of the Kumaon division has far more direct authority in regard to matters in Garhwal with which the Executive Engineer is concerned than is the case with the Commissioner of any other division. The Commissioner is Political Agent to Tehri-Garhwal from which all coolie labour is recruited, controller of the sadbhart fund, and also administrator on behalf of Government of the temples at Kedarnath and Badrinath and the pilgrim route generally. It is, therefore, essential for the Executive Engineer to be in direct touch with him and so located as to discuss matters whenever necessary. The Committee

urge that were it not for the pilgrim routes to Kedarnath and Badrinath, there would be no provincial roads in Garhwal. Further, the Conservator of Forests in charge of Garhwal is stationed at Naini Tal and with this officer the Executive Engineer has many dealings. If the latter were stationed at Dehra Dun they could never meet to discuss matters except on tour in Garhwal. In short the Executive Engineer if at Dehra Dun would be entirely out of touch with the officials who best know the needs of Garhwal. As regards the transfers of subordinates, it must be realized that only hillmen can work in Garhwal. If therefore Garhwal is placed under the jurisdiction of the Executive Engineer, Dehra Dun, it will be the only hill district in that division and, consequently, if a subordinate is needed for Garhwal, the Deputy Chief Engineer of the first circle of superintendence will have to apply to the Deputy Chief Engineer of the second circle of superintendence. The disadvantages of this need no elaboration. Apart from the multifarious duties that devolve upon the Executive Engineer, Naini Tal, and the further duties that will devolve upon him if the recommendations of this Committee are accepted, it is understood that the annual expenditure in the Kumaon division is uniformly higher than in any other division, which, if correct, is a further argument in support of the necessity for reducing the present size of the Kumaon division. Finally, the Committee expresses the opinion that with the difficulty experienced by touring officers in Garhwal, which is wholly devoid of cart roads, it is physically impossible for one officer to carry out the manifold duties of the Executive Engineer, Kumaon division, and it is therefore strongly recommends that the division be reconstituted on the lines suggested. If however the local Government are unable to accept this recommendation, the Committee request that the post of District Engineer, Naini Tal, be recreated and a senior officer of the rank of Assistant Executive Engineer appointed to it. To acquiesce in any slackness in supervising security works at Naini Tal is to jeopardize human life on a large scale.

I have the honour to be,

Sir,

Your most obedient servant,

G. L. VIVIAN,

Deputy Commissioner and President,

Hillsides Committee.

Enclosures-

- (1) Appendix A- List of drains.
- (2) Appendix B- Mr. Coulson's report (printed separately).
- (3) Appendix C- Letter of Executive Engineer, Naini Tal and its enclosures.
- (4) Appendix D- Mr. Kanji Lal's report.
- (5) Appendix E- Proceedings of the sub-committee of the Municipal Board of Naini Tal which met on July 15, 1927.

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... a few small drains on the north side of the ridge marked.

Drain no.	Length of drain.	Width of drain bed.	Depth of drain.	Section of masonry.	Year of construction.	Kind of masonry.		Condition of masonry.		By whom constructed.	Remarks
						In bed.	In sides.	In bed.	In sides.		
1	515	3 to 7	1 1/2 to 3 1/4	1 1/2	1880	Lime masonry.	Lime masonry.	Good	Good	Mr. Willcocks.	
a	670	1 1/2 to 3	1 to 1 1/2	1 1/2	1905	Do.	Do.	Do.	Do.	Mr. Gosde.	
b	278	1 1/2	1	1 1/2	1905	Do.	Do.	Do.	Do.	Do.	
c	578	1 1/2 to 2 1/4	1 to 1 1/2	1 1/2	1905	Do.	Do.	Do.	Do.	Do.	
2	1,186	1 1/2 to 3	1 to 2	1 1/2	1905	Do.	Do.	Do.	Do.	Do.	
a	310	1	1	1 1/2	1905	Do.	Do.	Do.	Do.	Do.	
b	10	1	1	1 1/2	1905	Do.	Do.	Do.	Do.	Do.	
c	226	1	1 1/2	1 1/2	1905	Do.	Do.	Do.	Do.	Do.	
3	308	2	1 1/2 to 1 1/2	1 1/2	1899	Do.	Do.	Do.	Do.	Do.	
a	109	1	1 1/2	1 1/2	1899	Do.	Do.	Do.	Do.	Do.	
4	450	1 1/2	1 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Mr. Willdehlrod.	
a	192	1 1/2	1 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Do.	
5	328	4	2 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Mr. Willcocks.	
b	1,599	2 to 5	2 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Do.	
a	61	1	1 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Do.	
p	147	1	1 1/2	1 1/2	1902	Do.	Do.	Do.	Do.	Do.	
c	200	2 to 3	1 1/2 to 2 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Mr. Willmotttting.	Require cement pointing.
d	596	2	2 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Mr. Willcocks.	
e	625	2	1 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Do.	
f	10	2	1 1/2	1 1/2	1880	Do.	Do.	Do.	Do.	Do.	
7	1,475	2	1 1/2	1 1/2	1906	Do.	Do.	Do.	Do.	Do.	
a	800	1 1/2	1 1/2	1 1/2	1896	Do.	Do.	Do.	Do.	Mr. Willdehlrod.	
8	1,569	2	1 1/2	1 1/2	1896	Do.	Do.	Do.	Do.	Do.	
a	150	1 1/2	1	1 1/2	1896	Do.	Do.	Do.	Do.	Do.	

No.		Date		Description		Quantity		Value		Remarks	
9	1,510	1	1 1/2	Lime maso- dry.	1896	1	1 1/2	1,510	Mr. Wildeblood.	Good.	
10	250	2	1 1/2	Do.	1896	1	1 1/2	250	Do.	Do.	
11	71	4 1/2	1	Do.	1896	1	1	71	Do.	Do.	
12	407	2 1/2	2	Do.	1880	1 1/2	2	407	Mr. Willcocks.	Do.	
13	266	1 1/2	1 1/2	Do.	1880	1	1 1/2	266	Do.	Do.	
14	2,350	3 to 4	1 1/2 to 2	Lime maso- dry & dry.	1880 & 1896 & 1903.	1 1/2	1 1/2 to 2	2,350	Mr. Willcocks, Mr. Wildeblood & Mr. Willmot.	Do.	
15	750	3	1	Lime maso- dry.	1880 & 1896	1	1	750	Mr. Willcocks.	Fair	
16	2,530	1 1/2 to 4	1 1/2 to 2	Do.	1896	1 1/2	1 1/2 to 2	2,530	Mr. Willcocks & Mr. Goode.	Good.	
17	682	1 1/2	1 1/2	Do.	1896	1 1/2	1 1/2	682	Mr. Wildeblood.	Do.	
18	758	2	2	Do.	1896	1	2	758	Do.	Do.	
19	336	1 1/2	1 1/2	Do.	1896	1	1 1/2	336	Do.	Do.	
20	100	1 1/2	1	Do.	1896	1	1	100	Do.	Do.	
21	15	1 1/2	1 1/2	Do.	1896	1	1 1/2	15	Do.	Do.	
22	445	2	1	Do.	1896	1	1	445	Do.	Do.	
23	344	1 1/2	1 1/2	Do.	1896	1	1 1/2	344	Do.	Do.	
24	60	1 1/2 to 5	1 1/2 to 2	Do.	1896	1	1 1/2 to 2	60	Do.	Do.	
25	2,365	1 1/2 to 5	1 1/2 to 2	Do.	1880	1 1/2	1 1/2 to 2	2,365	Do.	Do.	
26	1,245	1 1/2 to 5	1	Do.	1896	1	1	1,245	Do.	Do.	
27	192	1 1/2 to 5	1	Do.	1896	1	1	192	Do.	Do.	
28	440	2	2	Do.	1896	1 1/2	2	440	Do.	Do.	
29	83	1	1	Do.	1896	1	1	83	Do.	Do.	
30	326	1 1/2	1 1/2	Do.	1896	1	1 1/2	326	Do.	Do.	
31	10	1	1	Do.	1896	1	1	10	Do.	Do.	
32	2,140	1 1/2 to 4	1 1/2 to 4	Do.	1896	1 1/2	1 1/2 to 4	2,140	Do.	Do.	
33				Do.	1880	1 1/2			Do.	Do.	
34				Do.					Do.	Do.	
35				Do.					Do.	Do.	
36				Do.					Do.	Do.	
37				Do.					Do.	Do.	
38				Do.					Do.	Do.	
39				Do.					Do.	Do.	
40				Do.					Do.	Do.	
41				Do.					Do.	Do.	
42				Do.					Do.	Do.	
43				Do.					Do.	Do.	
44				Do.					Do.	Do.	
45				Do.					Do.	Do.	
46				Do.					Do.	Do.	
47				Do.					Do.	Do.	
48				Do.					Do.	Do.	
49				Do.					Do.	Do.	
50				Do.					Do.	Do.	
51				Do.					Do.	Do.	
52				Do.					Do.	Do.	
53				Do.					Do.	Do.	
54				Do.					Do.	Do.	
55				Do.					Do.	Do.	
56				Do.					Do.	Do.	
57				Do.					Do.	Do.	
58				Do.					Do.	Do.	
59				Do.					Do.	Do.	
60				Do.					Do.	Do.	
61				Do.					Do.	Do.	
62				Do.					Do.	Do.	
63				Do.					Do.	Do.	
64				Do.					Do.	Do.	
65				Do.					Do.	Do.	
66				Do.					Do.	Do.	
67				Do.					Do.	Do.	
68				Do.					Do.	Do.	
69				Do.					Do.	Do.	
70				Do.					Do.	Do.	
71				Do.					Do.	Do.	
72				Do.					Do.	Do.	
73				Do.					Do.	Do.	
74				Do.					Do.	Do.	
75				Do.					Do.	Do.	
76				Do.					Do.	Do.	
77				Do.					Do.	Do.	
78				Do.					Do.	Do.	
79				Do.					Do.	Do.	
80				Do.					Do.	Do.	
81				Do.					Do.	Do.	
82				Do.					Do.	Do.	
83				Do.					Do.	Do.	
84				Do.					Do.	Do.	
85				Do.					Do.	Do.	
86				Do.					Do.	Do.	
87				Do.					Do.	Do.	
88				Do.					Do.	Do.	
89				Do.					Do.	Do.	
90				Do.					Do.	Do.	
91				Do.					Do.	Do.	
92				Do.					Do.	Do.	
93				Do.					Do.	Do.	
94				Do.					Do.	Do.	
95				Do.					Do.	Do.	
96				Do.					Do.	Do.	
97				Do.					Do.	Do.	
98				Do.					Do.	Do.	
99				Do.					Do.	Do.	
100				Do.					Do.	Do.	
101				Do.					Do.	Do.	
102				Do.					Do.	Do.	
103				Do.					Do.	Do.	
104				Do.					Do.	Do.	
105				Do.					Do.	Do.	
106				Do.					Do.	Do.	
107				Do.					Do.	Do.	
108				Do.					Do.	Do.	
109				Do.					Do.	Do.	
110				Do.					Do.	Do.	
111				Do.					Do.	Do.	
112				Do.					Do.	Do.	
113				Do.					Do.	Do.	
114				Do.					Do.	Do.	
115				Do.					Do.	Do.	
116				Do.					Do.	Do.	
117				Do.					Do.	Do.	
118				Do.					Do.	Do.	
119				Do.					Do.	Do.	
120				Do.					Do.	Do.	
121				Do.					Do.	Do.	
122				Do.					Do.	Do.	
123				Do.					Do.	Do.	
124				Do.					Do.	Do.	
125				Do.					Do.	Do.	
126				Do.					Do.	Do.	
127				Do.					Do.	Do.	
128				Do.					Do.	Do.	
129				Do.					Do.	Do.	
130				Do.					Do.	Do.	
131				Do.					Do.	Do.	
132				Do.					Do.	Do.	
133				Do.					Do.	Do.	
134				Do.					Do.	Do.	
135				Do.					Do.	Do.	
136				Do.					Do.	Do.	
137				Do.					Do.	Do.	
138				Do.					Do.	Do.	
139				Do.					Do.	Do.	
140				Do.					Do.	Do.	
141				Do.					Do.	Do.	
142				Do.					Do.	Do.	
143				Do.					Do.	Do.	
144				Do.					Do.	Do.	
145				Do.					Do.	Do.	
146				Do.					Do.	Do.	
147				Do.					Do.	Do.	
148				Do.					Do.	Do.	
149				Do.					Do.	Do.	
150				Do.					Do.	Do.	
151				Do.					Do.	Do.	
152				Do.					Do.	Do.	
153				Do.					Do.	Do.	
154				Do.					Do.	Do.	
155				Do.					Do.	Do.	
156				Do.					Do.	Do.	
157				Do.					Do.	Do.	
158				Do.					Do.	Do.	
159				Do.					Do.	Do.	
160				Do.					Do.	Do.	
161				Do.					Do.	Do.	
162				Do.					Do.	Do.	
163				Do.					Do.	Do.	
164				Do.					Do.	Do.	
165				Do.					Do.	Do.	
166				Do.					Do.	Do.	
167				Do.					Do.	Do.	
168				Do.					Do.	Do.	
169				Do.					Do.	Do.	
170				Do.					Do.	Do.	
171				Do.					Do.	Do.	
172				Do.					Do.	Do.	
173				Do.					Do.	Do.	
174				Do.					Do.	Do.	
175				Do.					Do.	Do.	
176				Do.					Do.	Do.	
177				Do.					Do.	Do.	
178				Do.					Do.	Do.	
179				Do.					Do.	Do.	
180				Do.					Do.	Do.	
181				Do.					Do.	Do.	
182				Do.					Do.	Do.	
183				Do.					Do.	Do.	
184				Do.					Do.	Do.	
185				Do.					Do.	Do.	
186				Do.					Do.	Do.	
187				Do.							

No.	of drain.	Cut	ditch.	of mason- ry.	construc-tion.	Lime maso-nary in bed.	Lime maso-nary on sides.	Construction of roadway. In side.		Remarks.
a	1, 130	1 to 3	1 to 2	1½	Kinkadee- matt 1880.	Lime maso-nary	Lime maso-nary	Good	Mr. Willcocks.	Some por-tions req-uire relining.
b	228	1	1	1½	1880	Do.	Do.	Do.	Do.	
c	334	1½	1½	1½	1896	Do.	Do.	Do.	Do.	
d	110	1	1	1	1896 &	Do.	Do.	Do.	Do.	
e	138	1	1	1	1880	Do.	Do.	Do.	Do.	
f	225	3	1½	1½	1896	Do.	Do.	Do.	Do.	
g	332	1 to 1½	1 to 1½	1	1896	Do.	Do.	Do.	Do.	
h	512	1½	1½	1	1896	Do.	Do.	Do.	Do.	
i	386	1½	1½	1	1903	Do.	Do.	Do.	Do.	
j	115	1½	1	1	1880 & 1903	Do.	Do.	Do.	Do.	
k	335	2 to 3	1½ to 2	1½	1903	Do.	Do.	Do.	Do.	
l	66	1#	1½	1½	1903	Do.	Do.	Do.	Do.	
m	57	2	1½	1	1903	Do.	Do.	Do.	Do.	
n	300	1	1	1	1880	Do.	Do.	Do.	Do.	
o	182	1	1	1	1880	Do.	Do.	Do.	Do.	
p	105	1	1	1	1880	Do.	Do.	Do.	Do.	
q	1,526	1½ to 2	¾ to 1½	1	1896 & 1903	Do.	Do.	Do.	Do.	
r	2,560	2 to 6	1½ to 3	1½	1880	Do.	Do.	Do.	Do.	
s	510	1½	1½	1	1880	Do.	Do.	Do.	Do.	
t	550	2	1½	1½	1896 & 1903	Do.	Do.	Do.	Do.	
u	66	2	1½	1½	1896 & 1903	Do.	Do.	Do.	Do.	
v	340	1½	1½	1	1903	Do.	Do.	Do.	Do.	
w	58	1	1	1	1896	Do.	Do.	Do.	Do.	
x	870	1½ to 2	1 to 1½	1	1896	Do.	Do.	Do.	Do.	
y	158	1	1	1	1896	Do.	Do.	Do.	Do.	
z	810	2	2	1½	1880	Do.	Do.	Do.	Do.	

Year	Area	Quantity	Time	Condition	Remarks
1	20	1	1880	Good	Mr. Willcocks.
2	118	1	1896	Do.	Mr. Willcocks.
3	38	1	1896	Do.	Mr. Willcocks.
4	553	1	1896 & 1903	Do.	Mr. Willcocks.
5	83	1	1896	Do.	Mr. Willcocks.
6	507	1	1896	Do.	Mr. Willcocks.
7	2,574	1 to 5	1896	Do.	Mr. Willcocks.
8	46	2 to 2	1880	Do.	Mr. Willcocks.
9	270	1	1880	Do.	Mr. Willcocks.
10	265	1	1896	Do.	Mr. Willcocks.
11	490	1	1896	Do.	Mr. Willcocks.
12	160	1	1896	Do.	Mr. Willcocks.
13	4303	1	1896	Do.	Mr. Willcocks.
14	300	1	1896	Do.	Mr. Willcocks.
15	453	1	1896	Do.	Mr. Willcocks.
16	65	1	1896	Do.	Mr. Willcocks.
17	853	1 to 4	1880	Do.	Mr. Willcocks.
18	26	1	1880	Do.	Mr. Willcocks.
19	185	1	1880	Do.	Mr. Willcocks.
20	119	1	1896	Do.	Mr. Willcocks.
21	339	1 to 1	1896	Do.	Mr. Willcocks.
22	408	1	1880 & 1902	Do.	Mr. Willcocks.
23	3,340	1 to 10	1880 & 1903	Do.	Mr. Willcocks.
24	198	1	1899	Do.	Mr. Willcocks.

No. of animal.	Age in years.	Sex.	Color.	Measurements.	Remarks.	Disposition.
65	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
263	1 1/2 to 2	1 1/2 to 2	1 1/2 to 2	1 1/2 to 2	1 1/2 to 2	1 1/2 to 2
193	1	1	1	1	1	1
71	1	1	1	1	1	1
775	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2
181	1	1	1	1	1	1
1,367	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3
150	1	1	1	1	1	1
314	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
700	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
1,180	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2
678	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2
1,012	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2	1 to 1 1/2
92	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
195	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
58	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
100	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
50	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
547	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3	1 1/2 to 3
18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
39	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
771	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2
108	1	1	1	1	1	1
32	1	1	1	1	1	1
50	1	1	1	1	1	1
25	1	1	1	1	1	1
Total	62,925					
length.						

Drain No.	Length of drain.	Width of drain.	Depth of drain.	Section of masonry.	Year of construction.	Kind of masonry in bed.	Kind of masonry in sides.	Condition of masonry in bed.	Condition of masonry in sides.	By whom constructed.	Remarks.
23	5,840	1½ to 15	1½ to 6	1 to 2½	1880, 1896 & 1903	Lime masonry.	Lime masonry.	Good.	Good.	Mr. Wilcocks, Mr. Willdeblond and Mr. Willmott.	
24	474	1½	1½	1	1896	Do.	Do.	Do.	Do.	Mr. Willdeblond.	
25	960	1½ to 2	1½ to 2½	1	1896 & 1903	Do.	Do.	Do.	Do.	Mr. Wilcocks, Mr. Willdeblond & Mr. Willmott.	Some portions require relining.
26	290	1½	1	1	1896	Do.	Do.	Do.	Do.	Mr. Willdeblond.	
27	710	1½ to 2	1 to 1½	1	1896 & 1903	Do.	Do.	Do.	Do.	Mr. Willdeblond & Mr. Willmott.	
28	590	1	1	1	1896	Do.	Do.	Do.	Do.	Mr. Willdeblond.	
29	100	1	1	1	1896	Do.	Do.	Do.	Do.	Do.	
30	830	1½ to 3	1½	1½	1896 & 1903	Do.	Do.	Do.	Do.	Do. & Mr. Willmott.	
31	350	1½	1½	1	1896	Do.	Do.	Do.	Do.	Mr. Willdeblond.	
32	135	1	1	1	1896	Do.	Do.	Do.	Do.	Do.	
33	52	1	1	1	1896	Do.	Do.	Do.	Do.	Do.	
34	426	1½	1½	1	1896	Do.	Do.	Do.	Do.	Do.	
35	73	1	1	1	1896	Do.	Do.	Do.	Do.	Do.	
36	187	1½	1	1	1896	Do.	Do.	Do.	Do.	Do.	
37	206	1½	1½	1	1896	Do.	Do.	Do.	Do.	Do.	
38	10	1	1	1	1896	Do.	Do.	Do.	Do.	Do.	
39	70	1	1	1	1896	Do.	Do.	Do.	Do.	Do.	
40	1,090	2 to 15	1½ to 2	1½	1880	Do.	Do.	Do.	Do.	Do.	
41	58	1	1	1	1880	Do.	Do.	Do.	Do.	Mr. Wilcocks, Do.	

Drain No.	Length of drain.	Width of drain.	Depth of drain.	Section of masonry.	Year of construction.	Kind of masonry in bed.	In sides.	Condition of masonry in bed.	In sides.	By whom constructed.	Date etc.
21	186 581 292 41 56 2,023	1 1/4 1 1/4 1 1/4 1 1 1/4 1 to 6	1 1 1 1/2 1 1 1/2 1/2 to 3 1/2	1 1 1 1 1 1 1/2 to 2	1896 1896 1896 1903 1896 1880, & 1896 & 1901	Lime masonry. Do. Do. Do. Do. Do. Do.	Good. Do. Do. Do. Do. Do. Do.	Good. Do. Do. Do. Do. Do. Do.	Mr. Willdeblood. Do. Do. Mr. Willmott. Mr. Willdeblood. Mr. Willcocks, Mr. Willdeblood & Mr. Willmott. Mr. Willdeblood.	Some repair-able.	
25	116 12 12 200 539 350 426 2,435	1 1/4 1 1 1 1/2 2 1 1/4 1 1/2 to 3 dia. 1 1/4 to 5	1 1 1 1 1/2 1 1/2 1 1/2 1 1/2 to 5 1/2	1 1 1 1 1 1 1 to 3	1896 1896 1896 1896 1896 1896 1880 1880, & 1899 & 1902.	Lime masonry. Do. Do. Do. Do. Do. Do. Do. Do.	Good. Do. Do. Do. Do. Do. Fair Good.	Do. Do. Do. Do. Do. Do. Do. Do.	Mr. Willdeblood. Do. Do. Do. Do. Do. Do. Do. Do.	Dirty.	
26	4,080 140 1,860	3 1/2 to 5 3 1/2 3 1/2 to 4	2 1/2 to 2 3/4 2 1 1/2 to 3	1 1/2 1 1/2 1 1/2	1899 1899 1899 & 1906	Do. Do. Do. Do.	Do. Do. Do. Do.	Do. Do. Do. Do.	Mr. Willcocks Mr. Willcocks, along requi Mr. Willdeblood res relining & Mr. Willmott. Mr. Willdeblood. Do. Mr. Willdeblood & Mr. Goode. Mr. Willdeblood Do. Do. Mr. Willmott. Mr. Willdeblood. Do. Mr. Goode. Do. Do. Do.	Same por-tions requi-res relining	
34	192 340 247 217	2 1/2 2 1/2 2 1/2 2 1/2	1 1/2 1 1/2 1 1/2 1 1/2	1 1 1 1	1899 1899 1899 1902	Do. Do. Do. Do.	Do. Do. Do. Do.	Do. Do. Do. Do.	Mr. Willdeblood & Mr. Goode. Mr. Willdeblood Do. Do. Mr. Willmott. Mr. Willdeblood. Do. Mr. Goode. Do. Do. Do.		
35	1,156 1,088 1,878 334 153	1 1/2 to 3 1 1/2 to 3 1 1/2 to 3 1 1/2 1 1/2	1 1/2 to 3 1 1/2 to 3 1 1/2 to 3 1 1/2 1 1/2	1 1/2 1 1/2 1 1/2 1 1/2 1 1/2	1899 1899 1899 1907 1907 1907	Do. Do. Do. Do. Do. Do.	Do. Do. Do. Do. Do. Do.	Do. Do. Do. Do. Do. Do.	Mr. Willmott. Mr. Willdeblood. Do. Mr. Goode. Do. Do. Do. Do. Do. Do. Do.		

	Chain.	Link.	Length.	Station.	In use.	In side.	In bed.	Insides.	Constructed.	Remarks.
36	370	2 1/2 to 3	1 1/2 to 2	1880 & 1902.	Line masonry.	Good	Good	Good.	Mr. Willcocks & Mr. Willmott.	Pointing required
37	730	2 to 4	1 1/2 to 2 1/2	1880 & 1903	Do.	Do.	Do.	Do.	Do.	
a	60	1 1/2	1	1903	Do.	Do.	Do.	Do.	Mr. Willmott.	
b	17	2	1 1/2	1880	Do.	Do.	Do.	Do.	Mr. Willcocks.	
c	75	2	1	1880	Do.	Do.	Do.	Do.	Do.	
38	350	2 to 5 1/2	1 1/2 to 3	1880 & 1903	Do.	Do.	Do.	Do.	Mr. Willcocks & Mr. Willmott.	
39	220	dis. to 6.	1 1/2 to 1	1880	Do.	Do.	Do.	Do.	Mr. Willcocks.	Requires relining
40	1,740	1 1/2 to 2	1 1/2 to 2	1399	Do.	Do.	Do.	Do.	Mr. Wildeblood.	
41	950	1 to 3	1 to 2	1380 & 1399	Do.	Do.	Do.	Do.	Mr. Wildeblood & Municipality.	
a	135	1	1	1399	Do.	Do.	Do.	Do.	Mr. Wildeblood.	
b	11	1	1	1399	Do.	Do.	Do.	Do.	Do.	
42	328	1 to 2	1 to 1 1/2	1399	Do.	Do.	Do.	Do.	Do.	
43	1,582	1 1/2 to 7	1 1/2 to 3	1899	Do.	Do.	Do.	Do.	Do.	
a	484	2	1 1/2	Not known.	Do.	Do.	Do.	Do.	Do.	
b	790	2 to 3	1 1/2 to 2	1880 & 1903	Do.	Do.	Do.	Do.	Mr. Willcocks & Mr. Willmott.	
c	750	2 1/2 to 3	1 1/2 to 2	Not known.	Do.	Do.	Do.	Do.	...	
d	330	1 to 1 1/2	1 to 1 1/2	1899	Do.	Do.	Do.	Do.	Mr. Wildeblood.	
e	167	1 1/2 to 3	1 to 1 1/2	Not known.	Do.	Do.	Do.	Do.	...	
44	216	2	1 1/2	1899	Do.	Do.	Do.	Do.	Mr. Wildeblood.	
Total		41,501								
		length.								

[illegible]

[illegible]

[illegible]

[illegible]

Number.	Name of system.	Length.		Remarks.
		Miles.	Feet.	
I	Sherka-danda system.	62925'	11 4845	
II	Bare Nala system.	41,501'	7 4,541	
III	Sukha Tal system	9,951'	1 4,671	
IV	Ayarpette system	3,659'	0 3,659	
V	Beyond lake basin system	13,962'	2 3,402	
VI	Branches of Bellis ravine.	2,165'	0 2,165	
Total ...		134,163'	25 2,163.	

APPENDIX C.

Copy of a letter no. 7546, dated August 18, 1926, from the Executive Engineer, Kumaon Division, to the Chief Engineer, Public Works Department, Buildings and Roads Branch, United Provinces.

Excavation, removal of soil, quarrying, erection, re-erection of houses, etc., in the municipal area.

I have the honour to invite your attention to the enclosed extracts from Government orders dealing with the above. It will be seen from them that the orders on the subject have been changed and re-changed to a vast extent since 1880, the year of the landlip. The policy of relaxation, which has been pursued does not however seem to have been consistent.

With regard to the Sher-ka-danda area the following applies:-

In 1880 (vide accompaniment "A") the committee, which recommended absolute prohibition of erection of houses, quarrying, excavation of platforms, etc.

1880. Absolute prohibition of buildings, excavations, etc.

The Municipal committee appears to have ignored these recommendations as is evident from the Government order of 1895, dated July 10, 1895, para 5 (vide accompaniment "B"). In the same Government order Government passed very stringent orders on the subject and stated that no permission for such acts was to be valid without the sanction of Government. Government stated that only in exceptional cases would buildings be permitted and that excavation, etc., must be absolutely prohibited.

1895. Passing of more stringent orders by Government regarding building operations, excavations, etc.

Up to 1897, Government maintained this position very rigidly as will be seen from a letter no. 3485W-88, dated August 16, 1897, from the Under Secretary to Govt. to the Superintending Engineer, 2nd circle (vide accompaniment "C").

1897. Govt. refuses to reduce the area covered by the prohibited orders.

In 1899 (vide accompaniment "D") the municipal area was divided into three portions according to the degree of danger which was likely to be sustained by each from excavation, etc. The boundaries of an "exempted" area were clearly defined; those of the "prohibited" area had already been defined in Government order of 1895. In the exempted area applications for excavation, quarrying, and building operations, etc., were to be dealt with by the municipal committee entirely on its own authority. In the case of the "prohibited" areas the orders laid down in the Government order of 1895 were still to be followed rigidly. In the remaining area such applications could be sanctioned by the municipal committee with the previous written approval of the Commissioner.

1899. Certain delegations of authority to municipal board and Commissioner

In a separate Government order addressed to the Commissioner, Government in continuation of resolution no. 2166/XI-44-B of 1899, delegated powers of sanction to build on any part of the municipal area, except the exempted area, as well to dig or quarry within the same limits, except where these operations were absolutely prohibited under the order of 1895 to the Commissioner (vide accompaniment "E"). The Commissioner was to act on the advice of the Executive Engineer, or in cases of disagreement refer the case to Government for orders.

1900. Reduction
in powers of
municipal
board, as acc
rded in 1899.

1903. Grant of
further powers
to the municipal
board subject to obtain
ing District
Engineer's
or opinion.

1913. The position of the municipal board elaborated.

1927. Revised
by laws
concerning
powers of
Public Works
Committee of
municipal
board in all
matters.

Enclosures to the Executive Engineer's letter no.7546,
dated August 18, 1926.

In their remedial measure (para. 12) no. 6 of the report the

"The further erection of houses or other buildings, quarrying of stones and the excavation of terraces or platforms for any purposes whatever should be absolutely prohibited in the southern slope of Sher-ke-danda hill within the limits of east of Cheema Lodge, or west of Melville Hall."

"A"

Committee of 1880.

Para 5 of G.O.no.1939/XI-44B of 1895, dated July 10, 1895, states that with regard to the above recommendation of the committee of 1880 "Except as regards the quarrying of stones this has not been adhered to. The municipal committee have, from time to time, acting it is said on professional advice, granted permissions to the construction of buildings within the prescribed area, on the ground, it is said, that a well drained house is better than a badly drained site. In order to check the exercise of this power, the Government is pleased to direct that all such permission shall be submitted for confirmation of the Government before they are communicated to the persons concerned, and that without the confirmation of the Government no such permission shall be valid. It is only in exceptional cases and on perfectly safe sites that any building on the Sher-ke-danda hill will be permitted by Government in future. The excavation of terraces or platforms and the quarrying of stones within the limits specified by the committee of 1880 must be absolutely prohibited."

"B"

G.O.No.
1939/XI-
44-B, dated
July 10,
1895.

The Executive Engineer, Kumaon division, suggested to Government that certain land included in the area specified in notification no.1939/XI-44-B, dated July 10, 1895 (as quoted above) within the limits of which the erection of buildings without the special sanction of Government was prohibited should be excluded from that area. Government refused to alter the area in the letter referred to in the margin.

"C"

Letter no.
3485/88, dated
August 16, 1897
from Under
Secretary to
Government, to
Superintending
Engineer,
2nd circle.

In resolution no. 2166/XI-44-B of 1899, the whole area within the lake basin was divided into three parts.

"D"

Resolutio
no.2166/XI-44-B
of 1899 of Muni
cipal Department
dated August
30, 1899.

- (1) Exempted area :- In which permission of the municipal committee was sufficient as regards excavation, quarrying and building operations.
- (2) Prohibited area :- In which buildings, excavation of terraces and quarrying were absolutely prohibited except under orders of Government.
- (3) The remaining area within which quarrying, excavation and building operation could be sanctioned by the committee with previous written approval of the Commissioner.

The boundaries of the exempted area were distinctly mentioned in the appendix to Government order and these boundaries were marked on a map and the area were coloured.

G.O.no.2167/XI-44-B of 1899 from the Secretary to Govt. to the Commissioner, delegates the power of sanctioning building operations, including digging and quarrying in the area not prohibited and not exempted, to the Commissioner. The procedure laid down in the letter was as follows:-

No.2167/XI-
44-B of
1899, dated
August 30,
1899, from the
Secy.to Govt.
to the Commr.
Kumaon Dn.

The application was to be forwarded by the Commissioner to the Executive Engineer, Ayarpatta Provincial division, or such ^{other} officer of the Public Works Department as the Government may for the time being designate on their behalf. The points to be reported on were whether the proposed operations were likely to interfere with the public safety in general, or with the stability of any portion of the hillsides or with the security of any building, or with the safety of any person dwelling in the neighbourhood. The reporting officer might advise the vetoing of the proposals on any of these grounds, or he might recommend any conditions subject to which proposals should be sanctioned. If the Commissioner concurred with the opinion of the reporting officer his decision with conditions was to be communicated to the municipal committee. In case of disagreement, the case was to be submitted to Government for orders.

Para 3.-"The municipal board have already made a rule (printed at page 30 of their collected bye-laws) requiring the previous sanction of their Secretary to all blasting, quarrying, digging, cutting timber, or carrying on building operations in public or private grounds."

"F"
Proceedings
of the Govt.
in the Muni-
cipal Depart-
ment for Sep-
tember, 1900.
No. 1174/XI-44.
B. dated May 2,
1900, from the
Secretary to
Government, to
the Commis-
sioner.

" The Local Government must insist that no such sanction shall be given otherwise than at a regular meeting of the board, and that no such sanction shall be acted upon until it has been confirmed by the Commissioner in writing. The effect of this procedure will practically be to extend to the whole municipal area the protection given by the resolution of August 30, 1899. The cutting of timber must be added to the operations for which your previous sanction is required."

- " (a) Before sanctioning any excavation or the removal of soil, or quarrying, in the municipality Draft rules the board shall obtain and record the opinion under sec. of the District Engineer that the proposed action 187(1) will not endanger the safety of the hillsides. (a), Municipal Deptt no.357/XI-44 B- dated Feb. 12, 1900
- (b) The board shall within seven days of granting it ~~submit~~ submit to the Commissioner-
- (1) a copy of each sanction given by it for excavating, removal of soil or quarrying in the municipality;
- (2) a copy of each sanction given by it under section 87 of the Act to the erection or re-erection of any building."

In supersession of all rules regulating excavation, removal of soil, quarrying or cutting of trees, within the limits of Mairi Tal Municipality, certain rules were framed by the municipal board, Mairi Tal, under section 131, 132(1) of the United Provinces Municipalities Act, 1913. 1900 and confirmed by the Local Government.

Rule 5.- " On receipt of a valid application this board may either refuse sanction for any reasonable cause or subject to any rules framed by Government under section 187 of the Municipalities Act, grant sanction to do the proposed act. Such sanction may be either absolute or subject to the due performance of such condition as it may impose."

Rule 6.- "Within seven days of giving the sanction the board shall submit to the Commissioner a copy thereof for information."

Rules under 187(1) (a) regulating and controlling the powers of the municipal board, Mairi Tal, to sanction the erection and re-erection of buildings or excavations, removal of soil, and quarrying within the limits of the municipality and prescribing its duties in respect of such sanction.

Rule 5.- " The municipal board, Mairi Tal, shall not sanction the erection or re-erection of any building or excavation, removal of soil or quarrying within the limits of the municipality unless and until the Executive Engineer shall have certified that such erection or such excavation, removal of soil or quarrying is not in his opinion likely to affect the stability of the hillsides."

In supersession of all byelaws previously published on the subject, the following byelaws are made by the municipal board, Mairi Tal, under section 298, List II (a) and 299(1) of the United Provinces Municipalities Act (1916) and confirmed by the Local Government.

Byelaws prohibiting the digging of excavations, removal of soil, quarrying or cutting of trees in the Mairi Tal Municipality.

" Byelaw no.5.- On receipt of a valid application the Public Works Committee may either refuse sanction or grant sanction to do the proposed act. Such sanction may be either absolute or subject to the due performance of specified conditions."

Appendix D

REPORT ON THE DENUDED AREAS IN THE CATCHMENT AREA OF NAINI TAL LAKE.

I. Geological formation:

The geological formations round the lake basin may be classified as follows:—

1. Slate formations:

This consists of much broken slates and shales; varying in colour from shades of purple to grey or green which readily crumbles away on exposed surfaces; and bands of quartzite. On the higher ridges (Sherkadanda, Cheena &c.) this is capped by blue limestones, scattered outliers of which are also found in the lower portion on the east. Starting with the southern slopes of the basin just beyond the Talli Tal post office the formation curves round the lake to the Cheena hill and extends to a little beyond Cheena chowki below which it disappears under limestone formations. It reappears below the limestones again on the Ayarpatta hill and forms the south-western corner of the lake basin. In this hill it extends from about the middle of its length at the bottom to the municipal office on the west and upwards to about 7,000 feet.

2. Limestone formations:

This consists of massive bluish limestones which form very steep slopes often with large loose blocks. Starting with the Talli Tal post office it extends to the Ayarpatta hill where in the lower portions on the south-west it is replaced by slate formations as mentioned already. West of the Sleepy Hollow it again dips down to Barron's hill and Sukha Tal and extends upwards on the eastern slopes to a little beyond the Deopatta peak.

3. Scree material.

This consists of a mixture of angular fragments disintegrated from the steep scarps of China and spread out like a fan along the base of the China and Alma hills. The upper parts of this formation are unstable and steep; but lower down it forms gentler and comparatively stable slopes.

On the whole limestone formations, even when a little steeper, are more stable than the slate formations. On the south-eastern corner of the lake basin, on account of the dip and cleavage of the slate formation being often coincident with the slopes, the danger from slipping is the maximum*. The upper portions of the scree material formations are often steep and liable to slips.

It will be thus seen that the hill sides in greatest need of protection are:—

- (a) the Cheena slope.
- (b) Sherka-Danda-Alma slopes.

II. General description of the woody vegetation.

The principal trees in the station are the oaks tilonj (*Quercus dilatata*) and banj (*Quercus incana*) and their associates and cypress. Both the oaks are much mixed in the lower portions of the lake basin but in cooler situations and in the upper portions tilonj is the prevailing species. Where allowed to grow naturally as in the Municipal forests the oaks are associated with Kaul (*Alachilus odoratissima*); Ayar (*Pieris ovalifolia*); Hoblig (*Ilex odorata*); Ash (*Fraxinus floribunda*); in nalas; Poplar (on slips), Euonymus sp. Burans (*Rhododendron arboreum*, not common)

*Middlemiss: Records of the Geological Survey of India, Vol. XXIII.

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Khigsa (*Cornus macrophylla*), Maples &c. Cypress is the prevailing species in the China slope and also forms patches with oak on the Alma and lower parts of the Sherka-danda slopes. The shrubby growth is varied. Barua (*Daphne cannabina*); Bhati (*Deutzia Staminea*); Chamalia (*Desmodium tiliacifolium*) Saracococca pruniformis; Myrsine africana and semiser rata, Strobilanthes; honeysuckle (*Lonicera quinquelocularis*) &c. usually affect cool situations. Raudia tetrasperma, Leptadenia lanceolata, Ghari (*cotoneaster microphylla*); Jasmine, Colquohina Coccinea &c. occur usually in rocky places. Masuri (*Coriaria nepaliensis*) Debregasia sp. Rumex hastatus etc. favour slips and denuded spots; while Guia (*Viburnum continifolium*), kilmora (*Berberis* sp.) Chadul (*Rhamnus virgatus*) Indigofera sp. Hypericum sp. Brambles (*Rubus* species) Ghingarua (*Crataegus crenulata*) &c. are general.

Ringal (*Arundinaria falcata*) follows nalas in upper portions in Aparpatta.

The Ayarpatta hill with the exception of a small patch extending from below the Dereham house to the Rock House estate and to the Smuggler's Hall (Langham House) and another of smaller extent below Craig Cottage is well wooded. The upper portion of the hill constitutes part of the Municipal forest and is under protection. On account of the general formation and the well wooded condition of most compounds, there need be no apprehension about the safety of slopes on this hill. In some of the estates in the upper portions, tilonj is regenerating itself excellently whenever it has a chance and removal of old and deteriorating trees over these should be encouraged. On the Cheena slopes, the steeper and unstable portion is in the Municipal forest and well protected. The lower portion on stabler screes has been built upon. The slopes here are gentle and slips of any magnitude are not apprehended. The compounds on the whole are sufficiently wooded. The slope between Alma and Sherka-danda peaks with south-eastern and southern slopes are on comparatively unstable formations. The upper portion on the east is well-wooded but over the rest of the area there are several denuded patches some of which are subject to erosion. A number of compounds in this slope are very open and extreme caution is needed in dealing with applications for further fellings. It is indeed to be regretted that fellings were ever permitted which should have led to the present condition*. The removal of overhead cover has not been without its effect in disturbing the balance of shrubby and herbaceous vegetation. Even to the casual observer it has been probably increasingly evident how invasive rank growth like the nettle (*Gerardia heterophylla*) have replaced pretty wild and naturalised flowers like dahlia cosmos, &c., in this hill in spots where they were once abundant. While cutting has been in progress natural regeneration has been held in check, except in the sparsely inhabited upper portions of the hill by grazing by goats. It is however very satisfactory to note that this has been recently stopped on nazul lands where young growth is already responding to this protection.

A tracing showing the denuded areas in the catchment area is attached.

III. Statement of denuded estates.

The following is a statement of estates which are insufficiently wooded :—

Ayarpatta.

Langham House (Smugglers Hall)	...	{ Open at the top; planting suggested.
--------------------------------	-----	---

*1525 stumps from recent fellings have been counted on this hill.

*Rock House	...	{	Western portion blank, some trees may be planted and no further removals permitted.
Dereham House	...	{	No further fellings should be permitted from lower portion.
Langdale	...	{	Further fellings on the lower portions should not be permitted.
<i>Sherka-danda-Alma.</i>			
*Suffolk Hall	...	{	No fellings : should be planted with a few more trees.
*Upper Danda House	}	...	Very open ; <i>need planting up early.</i>
*Rohilla Lodge.			
*Stanley "			
*Ramsay Hospital (Lower part)			
*Albany Lodge.	}	...	Open in parts ; few trees should be planted. Fellings should not be ordinarily permitted.
*Upper Rolaston, May Villa			
Woodlands	...	{	Portion above the road well wooded, below it open ; planting to be encouraged,
*Tunstall Hall	...		No fellings to be permitted.
*Buttress Castle	...		Planting in lower portions to be encouraged.
Primrose Cottage	...		do. do.
Assembly Cottage	...		Planting not essential ; but should be encouraged to replace unsightly shrubby growth in lower portions.
Ravenswood	...		Few overmature trees may be taken out where interfering with better growth on the eastern portion. Planting to be encouraged in western portion.
*Tara Hall	}		Situated above the slip of 1880 ; further planting very necessary.
*Staff House (western part)			
*Maldon	...		No fellings should be permitted. There is a good deal of blank area in the estate where some planting is very necessary.
*Tara Cottage	}	...	Mostly denuded ; further fellings should be stopped. Planting should be encouraged.
*Tara Lodge			
*Brae House			
*St. Cloud	}	...	Blank on southern slopes ; planting indicated.
*Snow View			
*Alma Cottage	}	...	Very open ; planting to be encouraged.
*Oak Cottage			

*Oak Cottage	}	...	Fellings not safe; applications to be very carefully considered.
*Charlton Lodge			
*Springfield			
*Marshall Cottage			
*Upper portion of the Naini Tal Club estate			
Oak Lodge	}	...	Planting to be encouraged.
Brae-side			
Kumaon Lodge			
(western portion)			
Imperial Bank	}	...	The soil is exposed and while poplars are being removed nothing is being planted to replace them. This should be done early.
Poplars			

IV. Suggestions :

It need hardly be mentioned that the above remarks against the estates are to be taken in a general sense. Each application should be judged on its own merits. The slopes about the slip of 1880, are in greatest need of protection. It is unfortunate that the upper sections above this are already denuded. The willing co-operation of proprietors would perhaps be not easy to secure in planting up bare slopes. The experiment of having at least one tree planted and looked after for each felled may be tried. If this proves to be a success, top heavy trees (in estates which are not too bare) may be removed with advantage. The bare patches about the Ramsay Hospital and Rohilla Lodge; and in the estates above Maldon, the blanks about Rajpur are in need of being planted up very early. Estates like Harvey site, Debi Lodge, Philander Smith College are well wooded. In these the felling of old and overmature trees interfering with stems of better promise than themselves would be desirable. The trees should however be marked by a ranger or some one who has some conception of elementary forestry. Some of bare areas are nazul land. Planting these up would offer no difficulty. The old Government house estate should be maintained as a town forest except round immediate habitation, and cutting of trees should be ordinarily stopped. On the Aparpatta slope there is greater latitude for fellings but permissions should be given after considering local conditions in each case. As a general rule fellings should be done on more conservative lines on slates.

Cases would arise where removal of trees is necessary for admitting more sun and air to buildings. In the more open estates, if lopping should serve the purpose, it should be insisted on. The practice which some proprietors have got into of getting their fuel supply by denuding their estates of trees should be discouraged as far as possible.

Before planting on any effective scale could be expected, it should be made easy for proprietors to procure plants. The Municipality maintains at present a tiny nursery from which plants are sold. This should be extended and the rates reduced. It is difficult to induce anyone to take up planting seriously if he has to pay -/8/- for each plant. The best encouragement to planting would be to charge a very nominal price.

The most suitable tree for planting in the denuded portions of the Alma-Sherka-danda slope is the cypress. It is coming up in groups already on slips and bare areas and with a little trouble would readily extend itself. Its growth is faster than that of any of the oaks and its extension would certainly add to the picturesqueness of the station. In slips quicker growth is desired, for this poplar is the ideal species. It is readily propagated from cuttings and in a few years attains sufficient dimensions to be effective. As male trees have now been marked down; it would not be difficult to get a supply of cuttings from these and planting should lead to

no danger to sanitation. The species had found a natural home on the loose scree above the Imperial Bank and the Poplars. While many have been removed at the suggestion of the sanitary department, nothing has been done to replace them! Shrubs on the slip above this area should be encouraged; species like Masuri (*Coriara nepalensis*); *Rumex hastatus*; *Debregasia* &c. appear naturally at this elevation: in such places this natural growth may be augmented by planting.

A beginning may be made in planting such local trees which should at certain seasons add a touch of colour to the station. With this object more burans, painya (*Prunus cerasoides*) maples and horse chestnut may be introduced.

Introduction of naturalized dahlia, which several years ago was quite common about the station, is recommended to cover up small unsightly blanks on slate formations. It could be done at a nominal cost. If once it gains an upper hand over rank growth it soon propagates itself naturally. It would not be difficult to get house owners to interest themselves in putting down a few tubers in open unsightly spots on which at present nettles &c. are allowed a free run.

In this connection attention is invited to the recommendations of the special committee appointed to consider the revision of the working plan which met on June 20th, 1923. It is regretted that none of the suggestions in regard to planting have been carried out.

SUMMARY OF CONCLUSIONS.

1. The Sherka-danda-Alma slope is in need of being protected against further denudation.

In the estates marked with an asterisk trees should not be allowed to be cut except for very special reasons. In other estates in the list unless a real case is made out, permission should not be accorded. On the Ayarpatta slope with the exceptions mentioned permission for fellings may be ordinarily granted, but local conditions should be examined in each case. Permission for lopping may be readily given whenever it is needed for admitting more light or improving the view.

2. For every tree cut on the usual plea of over maturity and deterioration attempt should be made to have another planted and protected. In case of death of the initial plant it should be replaced by another and this is to be continued till one is established.

3. In blank nazul lands planting should be taken up early. The principal species to be tried are cypress, oaks and burans, if possible painya according to locality. On slips male poplars should be tried, and if very unstable, shrubs may be planted.

4. Strict protection of the young plants put in should be enforced.

5. In the case of well wooded estates fellings for improvement of existing growth should be encouraged.

6. The existing Municipal nursery should be extended and plants given to proprietors of estates at nominal prices to encourage planting.

7. The following species are recommended for planting in compounds:—

Cypress, oaks, maples, painya, burans, horse chestnut, angu, deodar. The choice of species will depend upon the locality. Deodar, horse chestnut, ash (angu), maples, would do well in cooler situation. Mehal (*Lyons Pashia*) although very pretty in spring should be replaced by other trees as it is the alternative host of the fungus *Gymnosporangium Cunninghamianum* which attacks the branches of cypress.

Sd. P. C. KANJILAL,
Deputy Conservator of Forests,
Naini Tal Working Plans Division.

APPENDIX E.

Proceedings of a meeting of the sub-committee appointed to consider the report drawn up by Mr. P.C.Kanji Lal on the denuded area of Naini Tal Lake, held on Friday, the 15th July, 1927, at 9.30 a.m.

Read the report submitted by Mr. P.C.Kanji Lal, Deputy Conservator of Forests.

In our opinion the following suggestions may be carried out to protect the hillsides and to remove the unsightly conditions, due to the denudation of the hillsides, within the catchment area of Naini Tal :-

- (1) On the slope between Sher-ke-danda and Alma peaks no felling of trees should be permitted except in special cases.
- (2) In the Ayarpatta hill only mature and dangerous trees may be permitted to be felled, except on estates extending from below Dereham house to the Rock house and to the Langham House, and below Craig cottage, where felling of trees should not ordinarily be permitted.
- (3) Judicious lopping of branches may be permitted in all estates where it is needed in the interest of light and air.
- (4) Permission of felling a tree should only be granted on the condition that it is replaced by another suitable tree where it is considered necessary by the Public Works Committee.
- (5) In blank muzul land planting of trees be taken in hand as soon as possible, with trees recommended by Mr. P.C. Kanji Lal, I.F.S.
- (6) No immature trees and young plants be allowed to be felled except for special reasons.
- (7) In the case of well-wooded estates felling for improvement of existing growth may be encouraged.
- (8) The existing municipal nursery may be extended, and, if necessary, other nurseries be established in suitable places. The suitable places for nurseries are:-

Compartment no. 13.- Ayarpatta Hill.

Compartment no. 1.- Near St. Lee Gorge.

- (9) The nurseries should be well stocked with plants recommended by Mr. Kanji Lal, I.F.S.
- (10) The price of plants supplied from municipal nurseries should not exceed annas two each to induce people to plant trees in the denuded areas.
- (11) All over the catchment area, where bare and unsightly patches exist, planting of dahlias, and other wild flowering, or ornamental shrubs and ringels should be encouraged.

REPORT BY MR. A.L. COULSON,
ASSISTANT SUPERINTENDENT, GEOLOGICAL SURVEY OF INDIA,
On the Hillsides of
NAINI TAL.

Dated NAINI TAL Sept. 25, 1927.

From---

A.L. Coulson, Esqr. Assistant Superintendent,
Geological Survey of India, Naini Tal.

To----

C.V. Kinsville, Esqr., Secretary, Hillsides Committee, Naini Tal.

Sir,

I have the honour to forward herewith reports upon the following localities in and around Naini Tal :--

- I. Cheena hill.
- II. Ballia Ravine.
- III. Kalakhan Hill
- IV. Charta hill.
- V. Durgapur power house.
- VI. Depot road subsidence.

With the exception of Charta hill, none of these localities are specially mentioned in the distribution of work adopted at the preliminary committee meeting.

Dated NAINI TAL, September 27, 1927.

From

A.L. Coulson, Esqr., Assistant Superintendent,
Geological Survey of India, Naini Tal.

To

C.V. Kinsville, Esqr., Secretary, Hillsides Committee, Naini Tal.

Sir,

I have the honour to forward herewith some notes upon items (F) and (g) of the terms of reference of the 1927 Committee. The notes have already been referred to in Messrs. Tunnicliffe and Lyle's and my joint note upon these items.

Will you please arrange to have a copy of the notes forwarded to me as well to the other members of the committee as I have no copy in my possession? Messrs. Tunnicliffe and Lyle are already in possession of a copy of the notes.

I also forward herewith some notes upon the drainage of Sukha Tal. I would also request a copy of these notes as again I have forwarded copies to Messrs. Tunnicliffe and Lyle.

NAINI TAL.

September 29, 1927.

Dear Sir,

I am forwarding herewith some additional notes upon the leakage from the lake (items (f) & (g)), receipt of which kindly acknowledge.

I have already forwarded a copy of the notes to Messrs. Lyle and Tunnicliffe, and have retained a copy for my own use.

Might I remind you that I would like a copy of my other notes upon items (f) & (g) forwarded with my letter of the 27th instant as I urgently require the same.

Yours faithfully,

A.L. COULSON

To

C. V. Kinsville, Esqr., Secretary, Hillsides Committee.

TERMS OF REFERENCE.

Item (a).—Maintenance of Existing Protective Works.

Mr. Spillsbury has already submitted a note embodying our joint conclusion that the existing protective works are, on the whole, adequately maintained and serve the purpose for which they have been constructed.

On the occasion of the rain of the last few days, the drains on the Sher-ka-danda dangerous area were inspected. It was found that with a prolonged quiet rain of the no great intensity, practically no water was discharged into the drains even after a fall of an hour. This is not the fault of the drains but is to be attributed to the extensive absorbing capacity for water of the shales and slates and to the degree with which the grass and tree covered soil cap retains the moisture and offers ready access for the water, in preference to allowing it to run off into the drains provided for the purpose. Such being the case, one cannot but expect a small percentage run-off for light rain. With heavy rain, however, the drains get ample opportunity to demonstrate their utility.

TERMS OF REFERENCE.

Item (b).—Need for Further Protective Works.

In various notes, most of the following additional protective works have been urged:—

- (1) Removal of the two large rocks above the East Laggan road.
- (2) Removal of the dolomite block on the Hermitage road which threatens the Metropole hotel.
- (3) Removal of the rock near pillar B.1 (Kaimukhet) threatening the Panikhet road.
- (4) The construction of revetment walls and drains upon the Gangipur spur near the Loolie Thara drains.
- (5) After the fall of the threatened area below the old police reserve lines, the provision of adequate drains and revetment walls.
- (6) After the fall mentioned in (5), the control of the Ballia from the Fairy Hall drain at least to its junction with the Mota Pani stream at Durgapur.
- (7) The provision of adequate drainage, etc., on the subsiding area of the Depot road.
- (8) The provision of adequate drainage, etc., on the threatened area in the vicinity of pillars nos. A-1, A-2, C-2 and D-2 on Salakhan hill and the prohibition of cultivation in this region.
- (9) Total demolition of Durga cottage and sloping off of this area, followed by afforestation. In this connexion, the old garden and mass of vegetation below Glenlee and the stable attached thereto might be cleared and grass planted, as at present water can readily enter the soil cap above a distinctly dangerous area. Also the tennis court could be made to have a rammed clay foundation if it does not possess it already. The rocks south of the lake fault line which passess just below Glenlee dip N. 30° E. at 45°; those north of it dip N. 75° E. at 16°. So the rocks in the vicinity of Durga Cottage have their maximum dips practically in the direction of slope and their dip is less than the angle of slope. Thus the conditions are exceedingly favourable for a slip.
- (10) At Galloway House, the apparent dip of the rocks in the direction of the slope is very little different from the angle of slope and this area is distinctly dangerous. It is for consideration whether or not the garden below Galloway House and between it and Kilminstone should be sloped off and grass covered or trees planted. Great care should be taken of the drainage in this area from Kilminstone to Glenlee as this region is practically as dangerous as the dangerous area of Sher-ka-danda hill. It would perhaps be advisable to erect pillars on the Glenlee, Rodcliffe and Galloway House spurs and record the annual movements of these in the annual reports. Also the erection of further buildings in this area could be prohibited.
- (11) Possibly sloping off of the tennis court at Fairlight Hall or the provision of a rammed clay foundation if not already existent.
- (12) Provision of adequate drainage above Maldon Cottage with possible sloping off of the vegetable garden of St. Cloud Cottage.
- (13) Drains of Sukha Tal.
- (14) An attempt should be made to stop the leakage of the lake under argrave House and the trees.
- (15) Afforestation on the slipped area of Manora hill.
- (16) " " " " Charta hill.

TERMS OF REFERENCE.

Item (a).--Maintenance of Existing Protective Works.

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On the occasion of the rain of the last few days, the drains on the Sher-ka-danda dangerous area were inspected. It was found that with a prolonged quiet rain of the no great intensity, practically no water was discharged into the drains even after a fall of an hour. This is not the fault of the drains but is to be attributed to the extensive absorbing capacity for water of the shales and slates and to the degree with which the grass and tree covered soil cap retains the moisture and offers ready access for the water, in preference to allowing it to run off into the drains provided for the purpose. Such being the case, one cannot but expect a small percentage run-off for light rain. With heavy rain, however, the drains get ample opportunity to demonstrate their utility.

TERMS OF REFERENCE.

Item (b).--Need for Further Protective works.

In various notes, most of the following additional protective works have been urged:--

- (1) Removal of the two large rocks above the East Laggan road.
- (2) Removal of the dolomite block on the Hermitage road which threatens the Metropole hotel.
- (3) Removal of the rock near pillar B.1 (Kaimukhet) threatening the Tanikhet road.
- (4) The construction of revetment walls and drains upon the Gangipur spur near the Coochie Thara drains.
- (5) After the fall of the threatened area below the old police reserve lines, the provision of adequate drains and revetment walls.
- (6) After the fall mentioned in (5), the control of the Ballia from the Fairy Hall drain at least to its junction with the Mota Pani stream at Durgapur.
- (7) The provision of adequate drainage, etc., on the subsiding area of the Depot road.
- (8) The provision of adequate drainage, etc., on the threatened area in the vicinity of pillars nos. A-1, A-2, C-2 and D-2 on Kalakhan hill and the prohibition of cultivation in this region.
- (9) Total demolition of Durga cottage and sloping off of this area, followed by afforestation. In this connexion, the old garden and mass of vegetation below Glenlee and the stables attached thereto might be cleared and grass planted, as at present water can readily enter the soil cap above a distinctly dangerous area. Also the tennis court could be made to have a rammed clay foundation if it does not possess it already. The rocks south of the lake fault line which pass just below Glenlee dip N. 30° E. at 45° ; those north of it dip N. 35° E. at 16° . So the rocks in the vicinity of Durga Cottage have their maximum dips practically in the direction of slope and their dip is less than the angle of slope. Thus the conditions are exceedingly favorable for a slip.
- (10) At Galloway House, the apparent dip of the rocks in the direction of the slope is very little different from the angle of slope and this area is distinctly dangerous. It is for consideration whether or not the garden below Galloway House and between it and Westminster should not be sloped off and grass covered or tree planted. Great care should be taken of the drainage in this area from Westminster to Glenlee as this region is practically as dangerous as the dangerous area of Sher-ka-danda hill. It would perhaps be advisable to erect pillars on the Glenlee, Indcliffe and Galloway House spurs and record the annual movements of these in the annual reports. Also the erection of further buildings in this area could be prohibited.
- (11) Possible sloping off of the tennis court at Fairlight Hall or the provision of a rammed clay foundation if not already existent.
- (12) Provision of adequate drainage above Maldon Cottage with possible sloping off of the vegetable garden of St. Cloud Cottage.
- (13) Drainage of Sukha Tal.
- (14) An attempt should be made to stop the leakage of the lake under argrave House and the cause.
- (15) Afforestation on the slipped area of Manora hill.
- (16) " " " " Charta hill.

TERMS OF REFERENCE .

Item (c).--(1) Existing Observation Stations.

With reference to the method of taking observations, I have no criticism to offer.

Regarding the position of existing pillars and page --

(A)--Sher-ka-danda.--Mr. Edgar's general conclusions in his note are agreed with. There appears to be an undoubted annual movement on practically all the spurs. It is not considered necessary to discuss the nature of the individual spurs as Sir Thomas Holland has already described the geological conditions of these, and his report may be referred to. One can but reiterate the warning that the drainage of the area is extremely important and should have special care. In this connection it might perhaps be pointed out that the drainage of the area above Malder Cottage is not considered adequate and free access into the Charlton Lodge spur is given to much water. An inspection should be made of St. Cloud Cottage, Bree Side, Bras House and the houses to the east of these.

Again the spur from Fairlight Hill to St. Helens and Blythe Cottage is far from safe and it is for consideration whether or not the tennis court at the first named house should be allowed in view of the catastrophic effects of a slip in this region.

The Edgchill and Ravenswood spurs should be carefully watched for any premonitory signs of a big slip.

The general location of the pillars is good and it is recommended that the present system of recording the annual movements be kept up.

(B)--Kalakhan Hill.--In a separate note (page 24), I have referred to the dangerous condition of this hill. With reference to the taking of observations it is recommended that they be taken from June 1 or, alternatively, from the beginning of the rains, instead of from June 15, as it is quite possible that the flooding of the area by a burst of rain at the opening of the monsoon would cause a slip to occur, since such water would have fairly easy access to the dangerous area on account of the abundance of cracks and fissures, consequent upon its prolonged dessication in the hot weather.

Reference to the bad site of the power house it has already been made in another note (page 22). The general direction of any slip on Kalakhan would be away from the Military Depot at Kalakhan and as the majority of the buildings constituting this are on the far side of the hill, it is not thought that the depot is in any imminent danger from a slip on Kalakhan; but the rifle range being on the Ballia side of the hill and situate above the old slip, is threatened to a certain extent.

(C)--Depot Road.--The Depot road has also been discussed (page 22) but with reference to point (3), it is not thought that the whole of the Depot road from Naini Tal can ever be secured on account of the fact that the natural condition of the rocks in the vicinity of the Bleak House spur are against stability. Here the rocks are highly crushed and the dip on the western side of the spur is in the direction of slip and at an angle very little different from the angle of slip. Further to the east towards the depot, the natural conditions are much safer and thought the slope is to the south, the general dip is 1 to between N.110° W. and N.100° W. and varies from 25° to 32° in magnitude. Any tendency to slip here is greatly diminished as the apparent dip in the direction of the slope (south) is equal to 8° only.

(a = apparent dip in direction of slope

d = true dip = 28° say

t = angle between directions of a and d = 180 - 105 = 75°

Then $\tan a = \tan d \cos t$

or $\tan a = \tan 28 \cos 75 = .138$

Thus a = about 8°)

The average angle of slope in this vicinity is about 33°. So there is sufficient difference between these for relative stability.

(D)--Charta Hill.--For reasons similar to those given for Kalakhan hill, it is for consideration whether or not observations should be started from the beginning of the rains and not from July 1.

It is considered that the existing arrangements for giving warning of impending slips, already tested satisfactorily in the slip of September 29, 1924 are sufficient.

Pillars nos. 1 to 11 are of use inasmuch as the study of their movements certainly gives indication of the retrogression of the slip line, e.g., pillar no. 11 has already proved its usefulness in giving warning of an impending slip

which in all probability will carry away the uppermost retaining wall. Again the pillars nos. 1 & 2 have foretold further imminent slips in their vicinity. For consideration of the need for additional pillars, see the ~~fact~~ following notes (also see pages 16--18).

(2) NEED FOR ADDITIONAL OBSERVATION STATIONS.

1. It is certainly advised that pillars be erected upon the spur of Kaimukhet above the Brewery bridge on the Bhowali side of the Ballia, their position to be determined by the location of the cracks which occurred in 1926. The existing pillars A-1, B-1 and C-1 record movements higher up this hill in a region which is at present fairly safe (they lie outside the cracked area of the hill). Before the threatened slip in the vicinity of pillars A-2, B-2 & C-2 and D-2 takes place, it is likely that premonitory symptoms will be indicated in the lower spur under discussion. Such being the case, the study of the movements of pillars erected on the lower spur above the Brewery bridge would be of great assistance.
2. In my note on the Ballia ravine (page 23), I have discussed the area below the old reserve police lines. This is an exceedingly dangerous area and every care should be taken to give adequate warning of an impending slip. Pillars could be erected on the soil covering of the spur, at the edge of the cliff and further inland and observations taken from the Bleak House station, if possible.
3. It is agreed that the Gangipur spur is another area that might well be observed. Though the conditions tend towards stability with the rocks dipping into the spur, the Ballia is at present uncontrolled at the foot of the spur and so is free to continue its work of destruction.
4. It is recommended that more pillars be installed higher up Charta hill. Even with the fall of the areas near pillars nos. 1 & 2, this hill will not reach a condition of stability and it is as well to be prepared for possible catastrophes. In addition, the spur between the slip of 1924 and the Durgapur stream running down from Manora should be watched, especially in its lower regions. With the cultivation at present allowed higher up this spur, free access is given for water to enter this spur. The possible disastrous effects of a slip here are too well known to be repeated.
5. As stated by Mr. Edgar, pillars on Matiali and Amparao areas would be of value.
6. I would also recommend that a pillar be erected on the Springfield spur.

TERMS OF REFERENCE.

ITEM (f).--Rainfall run-off, Assessment of Normal Leakages and Evaporation.

ITEM (g).--Verification of Catchment Area and Whether the Suka Tal Area should be included or not.

PERCENTAGE RUN-OFF OF WATER FALLING IN THE NAINI TAL CATCHMENT AREA.

1---Method of Calculation.---In the annual reports on the hill slopes around Naini Tal, a figure is always given to indicate the percentage run off of water falling on the Naini Tal catchment area. As an example, the figure for 1925, the lowest on record for the period 1905 to 1926, is worked out as follows:--

Catchment area of lake	...	1.9 sq. miles
Area of lake is	...	120.5 acres
1" rainfall on catchment area	=	$1.9 \times 12 \times 5280 \times 5280$
	=	44.14 lakhs c.ft.
12" rise on the lake	=	$120.5 \times 1 \times 4840 \times 9$
	=	52.49 lakhs c.ft.
Rainfall during the year 1925	=	98.48 inches.
Thus total volume of water which fell upon the catchment area	=	44.14×98.48
	=	4,352.82 lakhs c.ft.*
The volume of water discharged through the lake sluices and the power pipe line	=	1067.47+512.20
	=	1379.67 lakhs c.ft.
Lake gauge reading, January 1, 1925	=	3.92 feet

Lake gauge reading, December

31, 1925.

= 2.55

Difference

= 1.37

A gauge reading of 1.57 feet

= 52.49X1.57

= 71.91 lakhs c.ft.

Thus the percentage run-off

$\frac{(1579.67-71.91) \times 100}{4552.82}$

of rainfall

= 4552.82*

= 50.4 per cent

Thus the 50.4 per cent that is lost must include percolation before entering the lake, lost from the lake itself by percolation, evaporation, consumption by human agency, etc.

*This figure is that given in the Annual Report. The correct figure is 4346.31 lakhs c.ft. which will slightly modify the percentage run-off result.——A.L.C.

2. The figures for each year and the total rainfall since 1905 are given in the following table :—

TABLE I.

Year	Total rainfall in inches	Percentage runoff
1905.	91.61	75
1906	119.59	78
1907	65.73	66
1908	77.25	48
1909	139.67	75
1910	153.93	85
1911	100.62	62
1912	85.59	40
1913	26.11	47
1914	128.27	81
1915	138.32	59
1916	107.72	65
1917	137.76	37
1918	83.66	82
1919	123.72	69
1920	121.48	74
1921	110.30	65
1922	125.15	64
1923	96.12	60
1924	121.92	47
1925	98.48	30
1926	97.56	37

The rainfall for the years 1913 to 1924 is incorrectly given in the tables in the annual reports for these years as the rainfall during the monsoon; whereas it is the rainfall for the whole year. In the tables in 1925 and 1926 reports the rainfall for the years previous to 1913 is incorrectly stated to be that of the whole year; whereas it is the rainfall of the monsoon period alone. The percentage run off figures are taken from the 1926 annual report. It has not been found possible to check all these but certainly as will be shown later, the figure for 1910 (85 per cent.) is higher than the figure derived from calculations similar to those of para 1.

3. Lowness of figure for 1925—In an appended note to the 1925 annual report, Mr. S.G. Edgar, Executive Engineer, expressed grave concern at the lowness of the figure for 1925 as such figure may be considered as an index figure of the safety of the settlement.

4. 1888 Committee — The question arises whether the calculations by which the figure is arrived at are correct or not. The committee of engineers appointed by Government letter no. C/1741-EH, dated August 7, 1888, to devise means for the protection of the Ballia ravine, gave the following figures for the lake catchment area :—

"Total area of catchment of lake is 1.94 say two square miles or 1,280 acres. The area of the lake itself is 123 acres or 10 per cent of total area. Of the 1,157 acres outside the borders of the lake, 240 drain into Sukha Tal. On the west side of the lake and north-west of the lower basin there is an area of 150 acres, chiefly in limestone formation, of which little or no drainage directly flows into the lake during heavy rain.

In short, during the heaviest rain, very little drainage flows direct to the lake from the area of hillside west of a line joining Cheena Peak and the outlet bridge at the lower bazar. This embraces more than half the total area of the catchment basin..... The chief amount of drainage therefore comes from about 500 acres on the Alma and Sher-ka-danda side of the Naini Tal basin."

As will be shown in para 7 the conclusions of this committee are incorrect.

5. SUKHA TAL. --- The average rainfall for the 30 years ending 1924 was equal to 93.7 inches. A fall of one inch on the catchment area of Sukha Tal therefore---

$$= 240/640 \times 1/12 \times 5280 \times 5280 \text{ c.ft.} = 8,712 \text{ lakhs c.ft.}$$

Thus the average volume of rain falling annually in the Sukha Tal catchment are == 816.31 lakhs c.ft.

6. 1910.--In 1910, the year of greatest rainfall in the period 1905 to 1926, 153.93 inches of rain fell and the percentage run-off is given as 85 per cent., the highest figure recorded. Assuming the correctness of the calculations and assumptions in para 1, the volume of rain which fell in the catchment area of Naini Tal during 1910 = $44.14 \times 153.93 = 6794.47$ lakhs c.ft. The volume of water discharged from the lake in 1910 = 5108.43+318.56 = 5426.99 lakhs c.ft.

The difference in gauge reading = $4.00 - 3.70 = .30$ ft which equals 15.75 lakhs c.ft.

Therefore the total volume of water entering the lake = $5426.99 + 15.75 = 5442.74$ lakhs c.ft.

Thus the percentage run-off = $5442.27/6794.47 \times 100 = 80.1$ per cent and not 85 per cent.

7. SUKHA TAL AREA.--If it be assumed that the water falling in Sukha Tal catchment area in 1910 did not find its way into the lake, then the total amount of rain falling in the Naini Tal catchment area in 1910 would = $6794.47 - (153.93 \times 8.712) = 6794.47 - 1341.04 = 5453.43$ lakhs c.ft.

But the total volume entering the lake in 1910 was shown to be 5442.74 lakhs c.ft. and so if the water entering the Sukha Tal catchment area did not find its way to the lake, an absurd percentage runoff figure of 99.8 per cent is obtained.

So it is only reasonable to assume that as in 1910 most of the water entering the Sukha Tal catchment area found its way to the lake, the water caught there find its way to the lake under present day conditions (see also paras 23 and 24).

8. PERCENTAGE RUN OFF FOR MONSOON PERIOD.--The figures given in paras 2 and 6 are supposed to be those for the whole year. To find whether the figures are of the same order when considered for the monsoon period, an examination of the results for 1925 is given below for the period--May 30 to September 30.

TABLE II.
Discharges from lake in c.ft.

Month	Power	Sluices	Gauge in ft.	Rainfall in in
May	190,080	...	0.30	3.10
June	2,926,888	9,593,765		21.40
July	2,710,080	24,629,175		26.43
August	3,634,941	55,755,885		53.32
September	2,541,123	15,998,047	4.00	5.53
Total	12,003,122	105,978,872	+3.70	90.28

Total discharges from the lake = $120.03 + 1059.77$

= 1179.80 lakhs c.ft.

A gauge reading of 3.70 feet

= 194.21 lakhs c.ft.

Therefore the total water entering the lake = $1179.80 + 194.21$ lakhs c.ft.

= 1374.01 lakhs c.ft.

1" rainfall on the catchment area

= 3984.96×44.14 lakhs c.ft.

Therefore 90.28 inches

= 3984.96 lakhs c.ft.

Thus the percentage runoff during the monsoon season alone

= 1374.01

$\frac{3984.96}{1374.01} \times 100$

= 54.5 per cent. say.

Thus whilst 34.5 per cent enters the lake during the rains, 30.4 per cent enters during the whole year.

9. STORAGE CAPACITY OF LAKE.—It has been assumed throughout the foregoing calculations that the lake is waterproof or leakage-proof. This is far from being the case.

Lieut-Colonel F.D.M. Brown, in a report, dated September 26, 1882, stated—

"It appears that the Ballia river is not the only outlet of the lake. In the former years a large amount of water escaped by fissures leading through a subterranean passage under Ayahpata, below Wargrage House. Mr. Ryan states that he has seen the water of the lake at high level escaping freely through this channel, which is well known to exist.

"In former years the road below Wargrage House used to be more or less submerged when the lake was in flood. This portion of the road was therefore raised by the municipality in 1864-65 above flood level. The raising of the road has closed the mouths of these fissures, though some water still escapes by percolation. The water flowing through this subterranean escape finds its way out of the hill near the dhobis ghat, close by the police lock-up, on the south side of Ayahpata.

"This damming of this outlet probably started the destruction of fall no. 2 in the heavy floods of 1867 by sending an excessive quantity of water down the Ballia channel, and, by the course of the river, has damaged the whole of the hills on both banks as far as the Brewery, and will doubtless continue to do so as long as the whole of the lake discharge is forced down the Ballia channel."

10. SPRINGS.—At the time of the present investigation, a large amount of water was issuing from the springs at Gaumukh Dhara, Sipahi Dhara, Mota Pani and the Police line drain. It has not been possible to obtain figures of the flow from these springs but some rough test would be of great assistance.

11. Retentive capacity of lake in months of no rain:—However, the retentive capacity of the lake can also be studied by examining the figures of various years for months in which no rain fell in the catchment area of the lake. Such results as are obtained must be remembered do not take into account the gain to the lake by springs which continue for some time after the cessation of the rains.

Table III.

Month	LAKE GAUGE	Difference of Gauge	Gauge Difference	Loss by sluices	Nett loss.	Rain total
	Feet	feet	Lakhs C.Ft.	Lakhs cft.	Lakhs Cft.	Inches
December, 1907	1.60	0.10	5.25	..	5.25	65.75
December, 1909	1.50.					
November, 1909	3.90	0.40	21.00	..	21.00	139.67
	3.50					
November 1921	4.05	1.75	91.86	70.64	21.22	110.80
	2.30					
November 1922	4.80	0.60	31.49	15.19	16.30	125.15
	3.70					
December 1925	3.30	0.75	39.37	26.78	12.79	98.48
	2.55					

Thus there is to a certain extent an apparent connection between the total annual rainfall and the amount lost monthly by percolation, evaporation, etc. from the lake, the losses being greater in the years of large rainfall.

12. AVERAGE MONTHLY LOSS.—The average of the monthly loss from the lake given in the preceding paragraph is 15.31 lakhs of cubic feet. Assuming this to represent an average for all months in the year, then one has an average annual loss from the lake of 183.72 lakhs of cubic feet.

If this loss were included in the figures of 1925, the new figure for percentage runoff to the lake would be —

$$= \frac{1379.67 - 71.91 + 183.72}{4352.82} \times 100 = \frac{1491.48}{4352.82} = 34.3 \text{ per cent. say.}$$

So, providing that the gain to the lake by springs during the months of November and December may be neglected, the amount lost from the lake by percolation and evaporation has no appreciable difference upon the percentage run-off figure.*

*Both these conclusions have to be modified in view of the recent gauging of the springs south of the lake and the study of Mr. Lyle of the losses from the lake in dry months, when the gain from springs in the catchment area is far less than in the months of November and December. See also Appendix (3) to items (f) and (h).

13. COMPARISON OF LEAKAGE WITH AMOUNT USED BY THE HYDRO-ELECTRIC AUTHORITIES

As the figure given in the table III for the discharge from the lake for December, 1925, is solely that used by the hydro-electric authorities, there being no overflow from the sluices during that month, it is interesting to note that the average monthly loss by evaporation and percolation from the lake, as worked out above, is more than half that amount used monthly by the hydro-electric scheme.*

In the note appended to the annual report for 1926, it is observed that besides the discharges through the sluices and through the power line, there was a lot of leakage which amounted to about 6,000 c.ft. per hour. This leakage, it is stated, is from other and unaccounted for sources and is going on all the year round; but during the winter and summer months, it is much less than in the monsoon and all the leakage is pumped back into the lake during these months. For the four months July, August, September and October 1926, it was calculated that 150.72 lakhs of c.ft. were so lost but that the leakage for the other months may be neglected. This leakage figure was included in the percentage run-off figure for 1926, which was 37.3 per cent.

14. PREVENTION OF LEAKAGE WILL NOT CAUSE DAMAGE IN THE BALLIA RAVINE--

The additional discharge during the four months of the rains, if all leakage were prevented, would only amount to about 61 lakhs of cubic feet which is very small compared to 1067.47. So the prevention of leakage would not cause excessive damage in the Ballia ravine as postulated by Lieut. Col. F.D.M. Brown in 1882.

% In view of the data now available, the total leakage is much higher than 61 lakhs c.ft., but if the Ballia be adequately controlled, there is no reason to believe the extra discharge will cause excessive damage.

15. REMEDIAL MEASURES-- One is naturally expected to propose some remedial measures. In para 9 Lieut. Col Brown is already quoted as having stated that the raising of the road below Wargrave House closed the mouths of the fissures in that part. An examination in the field, however, does not hold out much hope of preventing the springs mentioned in para. 10 from discharging. The springs at Sigal Dhara, i.e. apparently issue at the junction of the dolomite with the shales. If these springs were blocked here, the water would issue from another place along the line of junction, or from the shales beneath, and in all probability cause excessive damage. At present they are effectively controlled at their points of exit.

The course of the water to these springs is undoubtedly through some sinkhole in the dolomite, thence to the plane of junction of this with the shales and so out at a convenient point on the hillside. It is probable that from the same sink hole in the dolomite is derived the water issuing at Gawnukh Dhara and Mota Pani but the water for these springs has found some convenient way through the shales and so issues at a lower elevation but in the same general line. All three springs feed the same stream which joins the Ballia just by the Durgapur power house.

Thus remedial measures must be applied at the fount of the spring, i.e. where they issue from the lake. At the time of inspection, the high level of the lake effectively prevented one from forming an accurate idea of the point or points from where the spring water leaves the lake; but it seemed highly probable that the defect lay somewhere below Wargrave House or the Chase. Accordingly it is suggested that this region be thoroughly examined when the lake is at a low level and that the usual remedial measures of lining the embankment and filling all likely holes in the dolomite with concrete be undertaken; but it is extremely doubtful if the fall of level of the lake will be sufficient to enable much to be done. This, however, is more in the province of the engineer than of the geologist.

16. ORIGIN OF THE LAKE-- Though much controversy has occurred in the past over

the origin of the lake, there is apparently no doubt at present that the dolomite at Talli Bazar is in situ and that the Ballia flows over such dolomite for about the first 1,300 feet of its course. So it appears certain that Naini Tal was formed by differential movements along the line of the lake--fault which occurred in post-Upper Siwalik times. The plane of this fault is possibly still a plane of movement at the present day and it is indeed fortunate that upto the present at least, no serious leakage of water occurs along this plane.

17. EVAPORATION:--The figure for normal leakage from the lake obtained in para 12 includes evaporation from the lake. With the evidence available at present, it does not seem to me possible to give a figure which will accurately represent loss by evaporation from the hillsides and also loss by evaporation from the lake. With additional data, this can, no doubt, be ascertained.

18. SUMMARY:--By a ~~xxx~~ study of the figures available, it has been proved that the water falling in the catchment area of Sukha Tal finds its way to the lake and that its catchment area should be included in that of Naini Tal lake itself. It has also been shown that the percentage run-off figure when calculated for the rains alone does not differ markedly from that obtained for the whole year. A figure has been obtained for the normal leakage and evaporation from the lake and it has been shown that, provided the gain to the lake from springs in the catchment area during the months of November and December may be neglected, this leakage does not account for the extreme lowness of the percentage g run off figure of recent year.

APPENDIX(1):--Since writing the above, I have managed to obtained the following figures for the consumption of water in Naini Tal settlement:

(a) Water pumped from the clear water reservoir:

1925	36,376,621 gallons
1926	37,789,130 "
1910	34,020,627 "

(b) Water pumped from the lake:

1925	1,231,260 "
1926	5,149,237 "
1910	Not pumped.

(c) High level gravitation supply springs:

1924-25	23,262,500 "
1925-26	16,677,000 "
1909-11	Figures not available.

Though the water pumped from the high level gravitation supply springs is for the term 1924-25 and not for the year commencing January 1, 1925, one can perhaps assume that the total water utilized in 1925 is $36,376,621 + 1,231,260 + 23,262,500$ gallons = 60,870,381 gallons = 97.40 lakh c.ft.

Also the total amount utilized in 1926 may be similarly calculated to be 59,612,367 gallons = 95.38 lakhs c.f.t.

Then the average total consumption of water = 100 lakhs c.ft. approx. which figure is small compared to the total average fall of rain and will have no appreciable difference upon the percentage run-off figure.

Considering the figures for 1925 again, we have

Total volume of water falling on the catchment area = 4352.82 lakhs c.ft.

The amount of water recorded in the lake and sluices = 1379.67-71.91 = 1307.76 lakhs c.ft.

The amount of water utilized in N.T. = 97.40 lakhs c.ft. (see page 1)

The amount lost by percolation and evaporation from the lake itself in the twelve months of 1925, by taking the average annual loss calculated in para 12 = 183.72 lakhs c.ft.

Therefore, the total amount accounted for = 1307.76 + 97.40 + 183.72 = 1588.88 lakhs c.ft. of water.

So the new figure for the percentage runoff obtained by taking into account loss from the lake and ~~xxx~~ consumption by human agency = $1588.88 \times 100 / 4352.82 = 36.5$ per cent say. (This figure is too small for the reasons given in the first footnote to para 12.)

APPENDIX (2): The following information was kindly supplied by

Mr. Hamsworth in continuation of the figures of the consumption of water in Naini Tal already given:--

"Item (a)--The 'C.W.R.' is clear water reservoir which obtains its supply from the combined main springs (of perennial character), north spring and east spring. All these three springs are caught within a water chamber getting its supply from the rain water falling in the Naini Tal catchment area (Ayarpatta side).

*The supply is not exhausted any year. The springs, however, get lower levels during the hot season and supply as the smallest quantity of water a little above 198,000 gallons per day. For instance, the 1925 was a very abnormal and dry season--the lowest reading in the clear water reservoir was measured on 4th June as 193,720 gallons per day. Hence the water supply was augmented from the lake (17th May to 22nd June--1,231,260 gallons).

"Item (b)--The lake water is first utilized generally by the middle of May till the beginning of the rainfall in the first or second week of July, depending entirely on the weather conditions.

"Item (c)--The water falling in the Naini Tal catchment area is quite independent of the high level gravitation supply from the three springs situated round about Cheena Peak (Tonnochy sub-district).

"This supply does not altogether cease to flow in a season of drought--the smallest yield being between 97,000 and a lakh of gallons of water--the rate of discharge varying according to the local rainfall of the area. The times of maximum and minimum discharge naturally occur after those of greatest and least rainfall, 30 inches of which is sufficient to stop pumping completely at an average from seven to ten weeks. In the year 1910, the pumping was stopped completely for three months, August, September and October.

"Subject to the above conditions, the total water supplied to Naini Tal during any one year, e.g. 1925 is the sum of a-b+c, since the lake water is mixed up with that in the C.W.R. before pumping to high inter and low levels of the water supply area of the station."

Considering the above notes, it appears that one may regard the following as the amount of water falling in the Naini Tal catchment area which is utilized for public purposes:--

1925:--Water pumped from the clear water reservoir==36,376,621 gallons
==58.20 lakhs c.ft.

~~This figure~~ This figure includes the lake water pumped as this water is mixed with the spring water in the clear water reservoir; also the high level gravitation springs apparently are fed from rain falling without the catchment area of Naini Tal lake.

This figure of 58.20, say 60 lakhs c.ft. of water is considerably smaller than that previously assumed (100 lakhs) and so Mr. Hamsworth has made additionally clear that the water utilized in Naini Tal will have no appreciable effect upon the percentage run-off figure; but such water utilized must be considered in any attempt to obtain a true figure for the run-off.

APPENDIX(3)--Through the kindness of Mr. Tumcliffe, I have managed to obtain the following information about the discharges of springs south of Talli Tal.

The Old gaugings of the springs are given in Mr. West's report upon the hydro-electric scheme as below:--

The actual minimum flow from Sipai Dhara, the two Krishnapur springs and Coolie Dhara--560 gallons per minute or 90 cubic feet a minute.

DETAILS--(1) Sipai Dhara R.L. 6,050; Minimum hot weather discharge =80 gallons per minute exclusive of the pipe lines to the jail, Cowhead spring and Krishna Sah's estate.

(2) Spring A. North of Krishna Sah's temple below the road to 'Mahal' R.L. 5,855. Discharge=240 gallons per minute.

(3) Coolie Dhara spring. R.L. 5,870. Discharge=240 gallons per minute. This spring makes its first appearance at R.L. 5909.02 but here it is situated below Rampur Sarai and it is not possible to collect all the discharge.

Later it was found that these figures were high. The results of testing the springs in May and June 1919 gave a total flow of 290 gallons per minute or 46.4 c.ft. per minute.

Details - Sipai Dhara	=	60 gallons per minute.
Mota Pani	=	10 " " "
Coolie Dhara	=	220 " " "

It is not unreasonable to assume an average flow throughout the whole year from all the springs fed by the lake of about 350 gallons per minute. If this be assumed, the total average annual loss from the lake by percolation alone would be --

$$= 350 \times 4/25 \times 60 \times 24 \times 365 \text{ c.ft.} = 350 \times 84,096 \text{ c.ft.}$$

If the mean flow of the springs be taken as 290 gallons per minute, the annual average loss from the lake would = $290 \times 84,096 = 243.88 \text{ lak.c.ft.}$

If it be taken as 400 gallons per minute, then the average annual loss = $400 \times 84,096 = 336.38 \text{ lakhs c.ft.*}$

* (In view of the result of the latest gauging of the springs this figure is probably far too small, the correct figure being of the order of 1,400 lakhs c.f.t.)

In my previous notes, the average annual loss from the lake calculated upon figures for November and December in various years was given as 183.72 lakhs c.ft. (para 12). This figure included evaporation from the lake. So it would seem that this figure is too small and the neglect of the spring water entering the lake during these months is not warranted.

It is for consideration whether or not the figure 500 lakhs of c.ft. can be taken as the average annual loss by percolation alone from the lake.

As an item for discussion, if figures cannot be obtained, it is suggested that evaporation might be of the order of about 60 lakhs of c.ft. per annum, this figure being for the lake surface alone.

Thus it is proposed that in future annual reports, the following additional figures could be taken into the calculation of the percentage run-off figure:--

- (1) Water consumed in "aini Tal ... Figures to be obtained annually from the water-supply authority
- (2) Loss by percolation from the lake ... 300 lakhs c.ft. annually
- (3) Evaporation from the lake itself ... 60 " " "

It is not known whether afforestation conditions of the present day are very different from those say of 1910 but it is considered likely that there is far more vegetation at present than in 1910. Information upon this subject would be welcomed and also any suggestions upon the allowance to be made for the changed conditions, if they exist.

SUKHA TAL AND SLEEPY HOLLOW.

19. Sukha Tal - The lowest part of Sukha Tal is at an elevation of 6,618 feet. It is a hollow bordered on its western, south-western and south-eastern sides by dolomite and on its north-eastern by screes. It is an ideal sink and it received the drainage of at least three main drains from China hill and also rain falling on part of Deopatia, the north-eastern slopes of Barron's hill and the northern and north eastern slopes of Handi Bandi. Most of this water finds its way by seepage towards Naini Tal (6,350 feet) and a possible line of passage of the water is along the lake fault north of Barron's hill and thence by Langdale and Pine View to the lake; however, there may be sink-holes in the dolomite which will give the water a different passage. Screes rising to a height of 6,670 feet at the Vicarage block its exit.

20. Sleepy Hollow - Sleepy Hollow is very similar to Sukha Tal. Its lowest level is 6,665 feet and it receives the drainage from the northern slopes of Ben Nevis, eastern slopes of Handi Bandi, the northern slopes of Ayarpatta and the southern slopes of Barron's hill. It is bordered on all sides except the western by shales. Its exit is blocked by screes rising to a height of 6,710 feet.

21. 1882 Committee--The committee appointed by G.O. No. 842, dated September 25, 1882, considered that no measures were required for the drainage of Sukha Tal as the expense would be prohibitive; and it further considered that the health of the station was not impaired by the retention of water during the rains. They noted, however, that the low corner of the graveyard on the west side is liable to be submerged and they recommended that no further interments be allowed here. It is understood that this recommendation has not been observed in recent years.

At the time of the current investigation, also, water was over the wall of the graveyard on the west side and numerous graves were submerged

some to a depth of more than three feet of water. It does not seem fitting that such a condition should be allowed to persist or even be remotely possible. Apart from considerations of seamliness, there are other reasons which necessitate the draining of Sukha Tal without further delay.

22. VOLUME OF WATER FALLING IN SUKHA TAL--In para 4 it was stated that the catchment area of Sukha Tal was 240 acres; and in para 5 it was shown that a fall of one inch of rain upon this catchment area was equal to 8,712 lakhs c.ft. and that the average amount of rain falling annually in this area was 816.31 lakhs c.f.t

Allowing a loss of one-sixth by evaporation and percolation before reaching Sukha Tal, and neglecting the evaporation from the tal itself there are thus about 4,252 lakhs of gallons of water yearly to percolate into the soil and rocks around Sukha Tal and do immense damage.

23. Contents of Sukha Tal--By a study of the contours and an examination in the field, the following are about the average dimensions of the sheet of water forming Sukha Tal in the monsoon:

Area	...	= 384,722 sq.ft.
Average depth		= 15 ft.
Volume	...	= 5,770,830 c.ft.
Contents of water		= about 361 lakhs of gallon

Thus whilst Sukha Tal normally holds about 361 lakhs of gallons of water, the average amount of water entering Sukha Tal annually is 4,252 lakhs of gallons.

24. Danger to settlement--Whilst water is allowed to collect in Sukha Tal, St. John's Church, the Deodars, Vicarage, Grassmere and the Metropole Hotel are in danger. All the houses are built upon screes and so have a far from stable foundation. At the time of inspection, a spring was said to have broken out behind the godowns of the Metropole Hotel. Also a large flow of water commenced to flow behind the godowns to the east of Langdale; this latter flow may be due in part to water percolating from a hole in the masonry drain from Sleepy Hollow. The slopes behind the Metropole are unsafely steep and it is difficult to imagine the catastrophic effects upon the whole of Malli Tal Bazar following upon the breaking away of the scree embankment at present holding the water in Sukha Tal. It is quite possible that the drainage of Sukha Tal would relieve the Glenles spur as this is on the line of the lake fault and so along the probable line of passage of the water to the lake.

25. Sleepy Hollow already drained--Sleepy Hollow is already drained by an open channel which joins on the Hatton Hall drain above Langdale. However, it is not considered that the present drainage is adequate as abundant water was noted.

26. Methods of draining Sukha Tal.--One possible method of draining Sukha Tal would be to use an underground drain from the centre of the Tal going through the dolomite of Barron's hill to exit by the posting box on the Hermitage road. Thence it could be brought as an open channel to join on to the Sleepy Hollow and Hatton Hall combined drain. The point of junction with this drain would be at an elevation of about 6590 ft. giving a fall of about 28 feet.

It was understood from Mr. Edgar that the expense of such a drain would be prohibitive. Accordingly, the most economic method of draining Sukha Tal would probably be by an underground drain through the screes under the Vicarage and Grassmere, to exist at about the 6,500 ft. contour in the main drain north-east of the Metropole Hotel.

TERMS OF REFERENCE.

Item(j)--REMOVAL OF THE LARGE ROCK ABOVE THE EAST LAGGAN ROAD AND NEAR KILLARNEY HOUSE.

Dr. E.H. Pascoe, Director, Geological Survey of India, Mr. Spilbury and I visited the rock called Craig Eilachie and we were unanimous that the rock in question should be removed.

In its present cracked and overhanging condition, it constitutes a grave menace to frequenters of the East Laggan road and the Lower Hall. Though the tell-tales inserted by the P.W.B. authorities show no movement, it must be remembered that the crack in which they are inserted is more or less horizontal in nature.

Geological reasons for the removal of Craig Ellachie have been given in the past by Oldham, Holland and Middlemiss and need not be amplified. It has also been understood from Mr. Spilsbury that the cost of removal will be less than the cost of the suggested repairs of the 1924 estimate. Again, with reference to these repairs, they will only postpone what appears to be an inevitable fall.

We were also of the opinion that the large rock above Craig Ellachie should also be removed as it is also so prominently cracked that it too is a danger to users of the roads beneath.

It is recommended that the work of removal be commenced from above and that on account of the possible danger by swamping by waves caused by the fall into the lake of large masses of rock, due precaution be taken to ensure that no one is on the lake at the time of removal of the rocks in question.

We also inspected a large mass of dolomite on the Hermitage road brought to the notice of the others by me. On account of grave danger to part of the Metropole Hotel, we were unanimous that it should be removed.

TERMS OF REFERENCE.

ITEM (1).--(1) EXAMINATION OF CHARTA HILLS.

Observation pillars.--Charta hill to the west of the Brewery was long a potential source of danger to the inhabitants of that settlement. In 1922 pillars were erected on the hill slopes and theodolite observations taken from a convenient station. Additional pillars were erected in later years and on September 29, 1924, a large slip occurred, burying many of the buildings and killing two sweepers. The warning of the impending catastrophe was given in time and the officials in charge are to be congratulated upon the efficiency of their observers. Other pillars were erected in 1925 and 1926 and the records of their movements are given in the annual reports for those years.

Of those erected in 1926, no. 11 was the only pillar which showed great movement. The following are the figures showing its total movements to date in inches :--

TABLE.

Pillar no. 11, Charta hill.

	1926.	1927 to Sept. 14, 1927.	Total to Sept. 14, 1927.
Horizontal	129.1	189.8	318.9
Vertical	131.6	206.3	337.9

The greatest movement of any other pillar in 1926 was that for no. 5, it moving horizontally 32.5 inches and vertically 34.0 inches. The fall of the region around pillar no. 5, however, be but local in effect.

PROBLEM AT THE BREWERY.--The present trouble at the Brewery is, in brief, due to the difficulty of controlling the water flowing over the debris of the 1924 slip. A rough and very diagrammatic sketch of the conditions at present existing in the upper part of the ravine (i.e. above the main road) is as follows:

The direction of the flow of water is shown by the read red arrows H to Q. After the slip, the main flow of water came in the direction HLP and it was found that this stream did excessive damage to the spur of Charta hill further to the south-east. So with great difficulty the flow was turned in the direction HLOP to divert the water from the junction of the debris with the shales, etc. of the hill spur and to give it a path through the debris. Soon, however, a great channel was scoured below Q and much money has been spent to prevent the water from doing damage.

In the floods consequent upon the rains of 1927, most of the protective works were washed away. At present, by means of the kacheha embankment R, the water is diverted to its original course, LP, in order that repairs may be made to the lower part of the channel Q.

The wall, ABC, is built upon foundations of rock which at C dip No. 80° W. at 52°; it has been silted up upstream. The rock is a phyllitic shale with stringers of reef quartz. The wall showed no signs of giving way at the time of inspection. The disastrous floods however along the course LOQ washed away the foundations of the wall DE on its

northern end E. These were on debris but those of the southern end D are on shales and sandstones. The floods have now exposed phyllitic Shales definitely insitu at the point S; these dip north at 30° .

The geological aspects of the problem here are whether or not the rock at S is insitu and what are the possibilities of obtaining rock further north, so that ultimately a wall could be built across the ravine to T. The construction of such a wall would not be advised on geological considerations. Rock is certainly available for foundations from D to S but the dip of the strata is not calculated to lend strength to the wall. Before the slip, rock must have been insitu in the portion ST, for the original stream course, as far as can be gathered, was some what on the line HLP and the present stream HLP, from P downwards, has again attained the bed of the old stream. The maximum depth of the gouging effect of the landslide must have been between S and T and, as S is some 20 feet below E, it will probably be necessary to excavate to almost that depth between S and T before a firm foundation can be hoped for. In addition, the spur T does not offer much hope of solid rock until considerable excavation has been made at T.

Thus the expense of building a wall from D to T of the requisite height and thickness to hold the debris in position from here would seem to be prohibitive.

Again, it cannot be long before the subsiding area in the vicinity of pillar no. 11 falls. It almost seems as if the wall ABC were playing a large part in supporting this area; but it is not probable that this fall could be avoided. When the slip does come, the wall ABC will go and even if a wall DEFT, or a wall on some similar alignment, were built, this, too, would most likely go with the sudden rush of water and debris. As little water as possible should be allowed to flow along the course LP and it is the writer's opinion that energies should be directed to achieve this and to repair lower part of the channel Q. The subsidence of the area around pillar no. 11 will, of course, entail great strain upon the discharging capacity of the channel Q.

As is natural after a slip of the dimensions of that of 1924, some considerable time must elapse before the scarred hill slopes are once again in a condition of relative quiescence. Mention has already been made of the probable subsidence of the area around pillar no. 11. By studying the figures for the movements of the other pillars nos. 1 and 2, it will be seen that since 1912, pillar no. 1 has moved 77.95 inches \times vertically and 242.49 inches horizontally, whilst no. 2 has moved 104.35 inches horizontally and 335.17 inches vertically. Though the movements in the last few years have been relatively small, sooner or later the area in the vicinity of these pillars will fall; the destructive effects of such a fall will not, however, be comparable to the catastrophe of 1924 but due allowance must be made in the constructive works for such an eventuality.

It is not thought that any relief would be obtained by diverting the water through the debris at some point east of T. This would only cause additional trouble and the problem would recommence along its original lines. In addition, the debris is gradually becoming more compact and there is every reason to believe that all care is taken of the channel Q the debris between it and the bridge road to Naini Tal will become in time as substantial as the debris of the 1898 slip to the north of the Brewery.

It is not proposed to discuss the problem of the control of the channel Q below the road as this is engineering in its nature. One cannot but express admiration for the work and resourcefulness of the engineers concerned, all works being of necessity constructed with great difficulty and on the insecure foundation of the debris, as, rock will only be met here insitu at a great depth under the existing surface.

In conclusion, it will be well to remember that the site of the Brewery is far from being safe. As long back as 1896, Middlemiss foretold that sooner or later the cracked area of Falakhan hill will fall and that its destructive effect will be much greater than the 1898 fall, as it will probably overwhelm the Brewery in its course. Also the spur of Manora to the south-west of the Brewery has been known to be cracked prominently (i.e. the spur with pillars nos. 12 to 20) and whilst present movements are small, the geological conditions, with dips varying from north-east to north to north-west, do not tend towards stability.

TERMS OF REFERENCE.

Item (1)--(2) EXAMINATION OF AMPARAO.

Problem--The problem at Amparao has already been stated by Mr. S.G. Edga who invited discussion upon the following points:--

- (1) Criticism of work done to date.
- (2) Consideration of steps to be adopted in the future.
- (3) Whether or not it will be advisable to vacate this area if the construction of a road elsewhere is feasible.

Middlemiss--The geological conditions are as follows. Middlemiss has noted the position of the great boundary fault between the Nahan sandstones of Lower Siwalik age and the older dolomites and shales of the Maini Tal area. According to him (memo. Geol. Surv. Ind. XXIV, pt. 2, p. 98) the main boundary fault up to the Ballia ravine continues in a fairly straight line cutting the Maini Tal--Kaladhungi road at Bijaun village, the Nehal R. near Nehalpur, the thence crossing a little S. of the Balne Khan and following parallel to and a little north of the Malena R. to Jole Kot. It is lost to view in the Ballia N. by a covering of superficial gravels....

"At the Ballia ravine this arrangement is broken by a cross-fault, a lateral wrench of the strata, plainly indicated by the swerving round of the dip towards it in the neighbourhood of the Malena bridge on the bridge road to Maini Tal from Ranibagh. The cross-fault follows a line very nearly coincident with the Ballia ravine, as far as the suspension bridge at Ranibagh."

Rocks at Amparao--Thus Amparao lies in a much dislocated and faulted area and the effects of the main boundary fault and the cross-fault upon the dips of the rocks is plainly visible. The main Nahan sandstone is easily picked out; it forms the high range behind Dangar and the range on the spur between the Malena and Ballia rivers, east of Amparao. Apparently forming part of the same Lower Siwalik series are interbedded argillaceous and shaly rocks and easily weathered, thin, highly jointed sandstones; it is to the peculiar characters of the argillaceous shaly rocks when saturated with water that the whole trouble at Amparao may be ascribed.

Hill '3,300' feet"--The chief trouble at present lies in the sinking of the road below the scarred face of the hill which rises to a height of 3,300 feet and from which slips have occurred and are still taking place. This hill is composed of bands of argillaceous shaly rocks which dip into the face in the direction N. 50°W at an angle about 7°. Below these are highly jointed sandstone beds which are found on the road between the slip and the drinking trough. These apparently dip E-W so that the geological formation is that of a dome. On the top of the hill 3,300 ft. are large blocks of sandstone which are not in situ. The natural conditions of dip, with the rocks dipping into the slope, tend for stability but the physical characters of the argillaceous shales are such that the natural conditions are powerless to prevent slips taking place. The downward pressure of the exotic superincumbent blocks assists the crumbling away of the scarped surface. There is thus an always increasing amount of debris at the foot of the scarped face.

Slipping Surface--The slipping surface is presumably the surface of the argillaceous material below the debris which is still in situ. This is kept lubricated by the percolation of some of the rain-water which falls on the surface at the junction of the scarp and the debris, but possibly to a greater extent by the percolation of the spring water. Behind the hill is a large area where intensive rice cultivation is carried on and the fields are flooded at certain seasons. Even when no flooding is carried out, sufficient water is present to keep up the flow of the spring. Here again the rocks forming the hill are powerless to prevent the passage of seepage from the fields, though such seepage must take some considerable time to penetrate through the hill to the slip.

Hand drainage methods unavailing--The debris of the slip, on account of its clayey nature, will not part with its water readily and normal methods of draining can never be successful. With abundant water present, the material is like a thick syrup and as such has welled over the large retaining wall at the foot of the slip.

Other faults present--Considering the dip of the rocks in areas close to the slip:--The sandstone by the drinking fountain dips N. 20° E. with an average dip of 25°. The dip of the sandstone forming the main ridge

behind Dangar is 36° towards N. 30° E. Towards Matiali, just past the closed nala about Verrieres wall, the dip is S at 28° . There is thus a violent disruption of dip north and south of a line running, as shown on the map, roughly at about N. 60° W through a point about 100 feet north of the drinking trough. This might be the rough alignment of the axis of a syncline but is more likely the line of a fault which has dislocated the strata, such fault being approximately parallel to the Ballia cross-fault already mentioned. Again the rocks are greatly disturbed on the eastern side of the Nalena river. It is difficult to obtain their dip but it apparently differs little from verticality. Also, apparently interbedded with the sandstone are bands of argillaceous rocks similar to those on the slipping portion of Amparao. The general strike is roughly N. 80° W. which is approximately parallel to the strike of the probable fault just mentioned and the Ballia cross-fault and the discordance in dip and general appearance of the rocks is sufficient to warrant the presumption of yet another fault somewhat along the line of the Nalena river. Consequently, with all the faulting and crushing that the area seems to have suffered, it is not to be wondered at that the sandstone in the Amparao area is highly jointed and fractured and the argillaceous shales have but little structural stability.

Alternative routes for road--There appear to be four possible alternative routes for the road:

- (1) In its present location.
- (2) Higher up the slipped area.
- (3) Behind the hill "3,300 feet".
- (4) Across the Nalena river.

(1) Present location of the road---So much money appears to have been spent upon the present road that it is a moot question whether or not it should be abandoned. It is not considered that the stoppage of cultivation was carried out in such a manner to render it a fair test. Accordingly it is suggested that as much water as possible from the streams discharging via the village Dangar to the south of the hill "3,300 feet" and thence over the main wall at the foot of the slip, and, also, all the water which at present discharges in the nala at Little Amparao, should be led around the foot of the sandstone hill to the north of hill "3,300 feet" (below the forest road) in a lined drain; thence it could discharge by a flume over solid sandstone into the Nalena river above Little Amparao nala. In addition, all the cultivated fields could be sloped off the rain-water falling on this catchment area could be led by a series of drains to a main central pukka drain, which would discharge into the nala flowing over the main wall.

It is agreed with Mr. Lyle that could a suitable flume be built on the spur between the main wall and Verrieres wall, to take the discharge of this nala without fear of harming these walls, the problem would be greatly simplified. If this be not possible, then the nala flowing over the main wall could perhaps be lined; it is, however, also agreed with Mr. Lyle that erosion of the top of the spur of the slip is more an effect than a cause of the continued subsidence. This being so, it would perhaps be better to use 'Armco' culverts to take the water, as such could be easily replaced if bent. Any system of concrete pipes is not advised as these would be sheared laterally and would thus soon cease to function.

As before stated, it is not considered that the debris could be adequately drained; but care should be taken to prevent as much as possible of the surface rain-water from finding its way into the material. This could be done by sloping off the surface and the provision of kachcha drains and by planting with suitable grass and, if possible, trees.

Provided that all the drainage methods above are followed, it is considered that the slip may possibly heal itself in time. There will always be crumbling of the scarped surface; but if the main wall holds, the slope will become more stable as its inclination becomes less. Such being the case, for three years at least, the present alignment should be given another chance. Undoubtedly further subsidence will take place, but one can be prepared to a certain extent for this and there need be no great dislocation of traffic.

(2) Higher up the slipped area--It has already been noted that the geological structure in the slipped area is that of a dome. Consequently the jointed sandstone found ~~in~~ at the present road level on the Kathgodam side of the slip will progressively become lower in elevation as one proceeds towards Naini Tal. So any attempt to clear the debris away below the scarped surface in the hope of finding a firm, if jointed, sandstone, and so a safe foundation for the road, will not be successful as the amount of excavation necessary would render the hillside more unstable than before and the present trouble would be greatly accentuated.

(3) Behind the Hill '3,300 feet'--From a rough examination, there would apparently be no insuperable difficulty in taking the road along the alignment of the old cart road from the Nalena bridge and thence above Little Amparao, leading it along about the 3,280 feet contour at the foot of the high hill behind Bangar. But this would add at least two miles of length to the road and would probably be prohibitively expensive.

(4) Across the Nalena river---A rough indication of the geological conditions across the Nalena river has already been given. Proceeding over the proposed new route of the road from the proposed new bridge at the Naini Tal, one first encounters highly jointed sandstone, the dip of which is difficult to determine but which seems to be vertical with a strike roughly N. 80° W. The hill slopes are very steep and the soil cap is variable in depth and contains numerous blocks of sandstone. Constructional difficulties would be fairly severe. About opposite Little Amparao was a slip which seemed due, chiefly, to the sliding of the soil cap over a conveniently placed joint surface. This slip would need careful attention.

Next argillaceous shaly soil is met, obviously derived from material similar to the Amparao side of the river. After rounding a sheer spur of sandstone, one apparently meets the same argillaceous material further along its strike, and it is on this that it is proposed to zig-zag down, then to cross the Nalena again on a firm foundation of sandstone. Passing on to regain the present road below the lowest slip on Matiali, one apparently passes over the two faults already mentioned; but though they are masked in the soil cap and cultivation of this area, the scarring of the surface by the construction of a road may just give the necessary impetus to cause slips to take place in a region at present apparently safe.

Summarizing, a road on the new alignment is undoubtedly feasible but geological conditions are very similar to those on the Amparao side, except that on the eastern side (Nalena side) the rocks apparently dip vertically instead of at low angles. There are thin bands of argillaceous shales interbedded with sandstone bands which will act to a certain extent as buttresses; but should surface water gain access to these argillaceous beds, it is quite possible that the history of Amparao would be repeated with the clayey material welling over their natural buttresses, so to speak. Still on this side, there does not appear to be the spring water that has been the major cause of the slipping on the Amparao side. In conclusion, it is not thought that the geological conditions across the Nalena are sufficiently favourable to warrant the abandonment of the present road and that the present alignment could be maintained, at least until proper drainage methods have been tried and found unavailing in the region above Amparao.

I. DURGAPUR POWER HOUSE.

The question has ~~now~~ arisen as to the stability of the foundations of the power house at Durgapur. As far as can be gathered from an examination in the field, the building is apparently built upon the debris of the 1898 slip from Kalakhan; but this is of no great thickness here, shales in situ being visible in the Ballia and Gausakh (Mota Pani) ravines. As Middlemiss described in his report, the debris temporarily filled the bed of the Ballia valley and dammed back its stream, also the Durgapur stream from Manora and the Mota Pani stream. "The debris surged up the opposite side of the Ballia ravine like a great wave which gradually solidified as it rose to its highest point on the opposite side and the contained water drained away."

The debris itself has had abundant time to become stable; but there are many reasons why the site of the power house is far from ideal. The drainage of the gardens and houses further up the spur is in a very bad state and abundant water can percolate into the debris and the underlying shales; the dip of these is generally into the spur and so tends to stability. The present trouble appears to be the result of the combined effect of the Mota Pani and Ballia streams cutting away the toe of the spur on which Durgapur is built, but protective measures, except for the adequate control of the Mota Pani stream, appear to be out of the question here until the Ballia is controlled in its course from the Fairy Hall drain up to this point.

The site is also rather unfortunate inasmuch as it is threatened by the probably slip foretold many years ago by Middlemiss.

II - SUBSIDENCE IN THE DEPOT ROAD.

Since 1910, pegs have been placed in that part of the old Bareilly-Naini Tal Trunk road near mile 1.4.226 and the annual movements of those pegs have been noted. The total movements in feet to 1926 for the various pegs are as follows :--

	Peg no. 1	Peg no. 2	Peg no. 3	Peg no. 4
Horizontal	5.35	8.25	2.71	8.38
Vertical	5.02	12.22	2.46	12.11

Generally the movement has been a slow subsidence, the greatest movement either horizontal or vertical of any peg since 1922 being 0.69 feet.

The rocks dip at 32° N. 100° W. just on the far side of the affected area from Naini Tal and between the subsiding part and the Bleak House spur, the dip is 25° N 100° W. In the upper road, a few hundred yards to the north-west of the area in question, the dip is 27° N 80° W.

The subsiding area is in a valley between two small spurs of Halakhan and the dips here, by the mass movement of the rocks, are greatly exaggerated. Between the depot road and the upper road, the place where the fracture has commenced can be plainly seen, the rocks being torn apart and part of the soil cap removed. The slopes are very precipitous and the movement cannot be else but a tendency, long delayed, of the hill to attempt to regain equilibrium after the scarring of the slope lower down by the old slip which occurred prior to 1898.

Provided that adequate means are taken to prevent surface water entering into the subsiding area at the fracture zone and other places, it is quite possible, though of course not certain, that further subsidence may be prevented.

III - BALLIA RAVINE.

As noted in the 1926 annual report, the safety of the lower end of Naini Tal down to Dargapur depends upon the Ballia ravine and its branches. At present the water in the Ballia flows under control to the Fairy Hall drain but thence onwards its course is free.

In its first part, the course of the Ballia is not far distant from the lake fault already described and its general direction is the same. The dip of the shales forming the eastern slopes of the Ballia is usually towards the river and as the angle of dip is generally less than the angle of slope, the conditions tend definitely towards instability. On the western side, however, the slates and shales dip under the dolomite and the conditions are far more stable. Thus steep slopes on the western side can be far more stable than less steep slopes upon the eastern side.

Considerable trouble has lately been experienced on the western slopes of the Ballia between the Fairy Hall and the Coolie lines drains. The barracks on the level ground above this region have been badly cracked and have rightly been vacated. One crack in the dolomite just on the edge of the ravine is fully two feet wide. Between the building nearest the edge and the main barracks is another crack, six inches wide in places, which has now been filled up with earth. Further in towards the bridle road, subsidence has occurred and large cracks have appeared in the buildings.

Proceeding down the scarped face towards the Ballia, one sees numerous cracks which have appeared in the surcharged revetment walls and a definite line of movement can be made out through the soil cap of the main spur.

Numerous slips have occurred in the lower part of this spur, causing much debris to fall into the Ballia. The net result of these has been to leave a scarped slope which approaches verticality. The whole area is distinctly unsafe; at the time of investigation, small screens were falling continually into the Ballia and it was with great difficulty that a transit could be made across a moving scree slope which had obliterated, for some distance, the path which leads upwards from the Ballia to the Gurkha barracks spur.

Rain-water, as usual, has been the chief destructive agent and the heavy rains of the current monsoon have added their quota of damage to the damage begun by the preceding rains. The soil cap has become sodden with water and this has percolated down to the shales beneath. In addition, one of the lines of leakage from the lake enters almost at the junction of the dolomite with the shales at this point. A spring occurs below the slaughter house, others in the vicinity of the Fairy Hall drain, but the main flow is into the drain below the Gurkha barracks (see below). There is thus abundant underground water available to sodden the rocks of the spur in question.

the pillar A and presumably along the main crack. Cultivation is also carried on in the dangerous area and rain-water can readily enter the soil cap and so into the rocks.

The question arises whether or not it is worth while taking such preventive means as can be made, in order to delay as long as possible a landslip that is probably inevitable. In the consideration of the report of 1907 Committee, it was noted that the committee hoped that the gradual downward movement of the surface, attended by small slips, would relieve the stress without leading to a great catastrophe. But Middlemiss had already noted (Kalakhan landslip, p.7) that though the preliminary indication of the 1898 slip were those of a general slow down-hill movement of the surface layer, the final culmination was that of a sudden rock-water avalanche. He also noted, however, that the scarred hillside 'may heal up'.

The destruction caused by the fall of the area around pillars A-2 B-2 C-2 and D-2 would be immense, as this area would not only overwhelm Durgapur but also cause great damage to the Brewery settlement. The fall of the area around A-3 B-3 and C-3 would possibly have less catastrophic action, though it would certainly dam the Ballia and so threaten the power house.

Such being the case, in view of the interests at stake, it is certainly thought that protective works such as adequate drains, prohibition of cultivation, afforestation, etc., should be taken in order to assist in the possibility that the hillside may heal up.

In conclusion, near the pillar B-1, some of the overhanging rock could be removed in order to avert possibly danger to the frequenters of the Brewery-Ranikhet road below.

The Depot road subsidence has been discussed separately. (page 18)

V. -- CHINA HILL.

R.D. Oldham---Many observers have pointed out in the past that the geological conditions of China hill are such that continual falls of material may be expected. In a note, dated September 21, 1889, R.D. Oldham stated that "the steep crest of China ridge is an extremely scarped face of rocks from which periodical rock-falls must be expected; but there is no other danger to be apprehended on this hillside. Preventive measures are here out of the question; nothing short of the removal of the whole scarped cliff by blasting would be effectual, and this is of course impossible. As a protective measure I consider the proposed system of terraces is the best that could be adopted"

~~GENERAL~~ GENERAL DIP -- The general dip of the rocks forming China and to the south-west of China is between 8° and 10° to the south-west and so if there were any tendency to slip in this region, the general direction of the fall would be to the far side of China away from Naini Tal.

Whilst shales form the lower part and summit of China, there appears to be an interbedded band of dolomite encircling the hill. The shales also have thin sandstone bands interbedded with them and are extremely well-jointed, the resultant effect of two sets of cleavages; thus by the action of water percolating along the cleavage planes and so dismembering the shales fragments are continually falling. The consequence is that the scarped face towards Naini Tal is always ~~xxx~~ tending towards verticality in its upper parts, whilst there is an increasing apron of debris in the lower parts. Whilst one cannot do anything to affect the stability of the upper regions, it certainly is possible to prevent a great amount of water entering the apron of debris and so reducing the co-efficient of friction of this.

China is joined to Alma G.T.S. by a narrow spur formed of shales, the dip of which varies in direction from south-west to north-west and in magnitude from horizontality to 20° . The general direction of any slide in this region would be to the west-north-west or west-south-west, and whilst the former direction is away from the settlement, the latter direction is towards the southern debris slopes of China facing the settlement.

Protective measures at present in force are afforestation, rock barriers, ditches, etc. and masonry drains to get rid of rain-water as quickly as possible. ~~xxxxxx~~ One can suggest nothing further but add that the hillside will always be a source of danger from falling material until at least 500 to 600 feet of the surface have been eroded off.

There is a ditch above Oak Park and Mohan Park which has been constructed for the purpose of stopping debris falling on to the houses below. At present this has a fair amount of debris in it and a lot of vegetation. There is supposed to be an exit to the south-west into one of the drains for water collecting in the ditch but this exit is blocked. Under these conditions, the ditch allowed water to percolate into the debris below and it is a sink for the drainage of the valley from China in which lies the path from the Toll House to the Waterbury Road.

Whilst not suggesting that all vegetation should be removed from the ditch, it is considered that enough vegetation and debris should be cleared to allow free exit of water from the eastern end of the drain. Incidentally the same remarks apply to the ditch above the junction of Tomnoky road with the Upper China Wall.

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*Approved
24/9/70*

**Report of the Committee appointed by H. H. the
Lieutenant-Governor to examine the hill
Slopes around Naini Tal.**

1907.

1. This Committee was convened by order of H. H. the Lieutenant-Governor, dated the 1st September 1907, and consisted of the following members :—

MR. C. H. BERTHOUD, I. C. S....	<i>Officiating Commissioner of Kumaon,</i>
MR. A. C. POLWHELE	<i>... Superintending Engineer, Allahabad</i>
MR. F. O. OERTEL...	<i>... do. Lucknow</i>
MR. A. B. GALE ...	<i>... Executive Engineer, Kumaon Division</i>
MR. A. PERKS ...	<i>... Municipal Secretary and Engineer, Naini Tal.</i>

2. The Committee have examined very carefully the slopes, drains, etc., on the whole of that portion of Sher-ka-danda which is known as the "prohibited area" i. e. the area lying between Melville Hall on the south-east and Cheena Lodge on the north-west. They have also visited, as far as time permitted, certain other localities which seemed to require inspection, such as the terraces below Cheena, the slate slopes of Ayarpatha at the north-west end of the lake, the East Laggan spur, the Depot or Kalekhan hill and the Ballia ravine.

3. *Previous History.* Before recording the result of their inspection the Committee think it desirable to refer briefly to the reports and recommendations of previous committees and the principal orders which have been issued from time to time on the subject.

The substance of the reports of the various committees and geological experts prior to 1896 beginning with that of the committee of 1867, is summarized by Mr. T. H. Holland, Director Geological Survey of India, in his report of 1896, but there are certain points which seem to call for special notice.

I. SHER-KA-DANDA.

4. Report of the Ramsay Committee of 1880.

Para 6. The 1880 committee found that the southern slopes of Sher-ka-danda between Melville Hall and Cheena Lodge had been seriously shaken and injured by the violent rainfall of the 16th to 18th September 1880, assisted by the reckless manner in which the hill had been disturbed to form sites for houses and gardens.

Para 7. The committee attributed the injury mainly to the cutting up of the face of the hill to form roads, sites for houses, gardens, tennis courts etc., which had operated in three ways :

- 1st. By concentrating the flow in the ravines and so causing scour and consequent slips.
- 2nd. By admitting large quantities of water into the interior of the hill which passing along the strata, caused one layer to slip on another or scoured channels and so undermined the superincumbent mass.
- 3rd. By admitting water which, being unable to escape, and saturating the hill-side rendered it liable to slip on the slightest disturbance.

Para 8 and 9. The 1880 committee were of opinion that the series of slips and cracks which had occurred were not necessarily connected and that there had been no general subsidence.

Para 11. They considered that there was no insuperable difficulty in dealing with such a series of disconnected slips but that, until preventive measures were taken, slips would go on.

Para 12. They advocated the following measures :—

- (1) and (2) Ravines to be lined and revetted.
- (3) Fissures to be filled with clay.
- (4) and (5) Platforms and terraces to be covered with 6 inches of rammed clay.
- (6) Further erection of buildings, quarrying and excavation of terraces or platforms to be absolutely prohibited.
- (7) All houses to have eaves gutters and masonry drains leading to the nearest ravine.
- (8) House proprietors to be compelled to build and restore retaining walls, and to slope off the hill above the walls to an angle of 40° with the horizon.
- (9), (10), (11), (13) and (14) The civil officer in charge of the station to be responsible for all water-courses and roadside drains ; to have an inspector under him and to appoint gangs in the rains to clean and repair drains. All works which effect the stability of the station to be carried out under his orders with the advice when necessary of the Superintending Engineer and without reference to the

municipality. House and landowners to pay the cost of such works on their estates but not to carry out the works themselves.

- (12) Steep slopes to be turfed and planted. No grass cutting or grazing to be allowed.

Para 24. Regarding the mission premises the committee wrote "The hill above these is cracked in all directions.....the committee consider that no reasonable expenditure would render this hill perfectly safe and recommend that the premises should not be re-occupied.....that a dangerous slip will sooner or later occur at this point there can be no doubt." *

Para 26. The committee were of opinion, that neither the Mayo Hotel (now known as Grand Hotel) nor Morrison's shop (the Exchange) were safe and that no reasonable expenditure could remove the danger to which they were exposed.

5. Mr. R. D. Oldham, Geological Survey of India, in his note on the landslip of 1880 wrote..... "All through last rains small slips occurred (*i. e.*, prior to the big slip of 18th September).....We must condemn the hillside from a line running up from Bank House (Lawrie's photographic studio) to a line running down from a little to the west of Fairlight Hall (Tonnochy's).....that part extending from the old landslip to the stream to the east of the mission premises must fall in a few years."

6. Mr. H. C. Conybeare I. C. S. writing of the landslip of 1880 described the conditions as follows :

Para 7.....As early as 1860, writes Major Garstin, the Victoria Hotel was considered unsafe.

Para 8. During the present year Dr. Walker noticed that the whole hill crust had sunk some 6 inches from a crack in the lofty road known as the upper mall. Warning was given and the municipal committee decided torevet the ravine.

Para 9. Some people held that the landslip was due to slight earthquake shocks which were felt on that day but the general impression was that it was caused by the saturation of the crust with water owing to the excavation of fresh building sites on the ridge of the hill.

Para 10. 20-25 inches of rain fell in the 40 hours prior to the landslip† and several brown torrents were brawling down the hillside.

* The mission premises were kept vacant for 5 years after which they were allowed to be reoccupied.

† The total rainfall on the 17th, 18th and 19th September 1880 as gauged by Mr. J. S. Beresford at Alma House amounted to 33 inches. The landslip occurred on the 18th at 2 P. M. after 22 inches of rain had fallen. The Sher-ke-danda hill therefore stood a further continuous rainfall of 11 inches up to 4 P. M. on the 19th when the rain ceased.

Para 11. The first damage to the Victoria Hotel was done by the fall of a tree which dragged a considerable quantity of shale with it.

7. The committee appointed in 1882 to report on the protective works of Naini Tal observed that the recommendations of the 1880 committee had all been carried out except the covering of platforms and terraces with clay, and the prohibition of gardens and cultivated terraces, but that platforms and terraces had generally been drained into ravines. Regarding certain houses they remarked as follows :

Ravenswood:—...“ Apparently all houses situated near the head of the Ravenswood ravine seem liable to crack every year which points to some continuous settlement or dragging of the ravine. ...The site (of Ravenswood) however, is not condemned.

Edgehill :—This house has shown no sign of disturbance during the past two years.

8. In 1883 a committee was convened to enquire into the condition of the old Government House on Sher-ka-danda. This committee was of opinion that the cracks through the house which were all longitudinal, were consequent upon the general disturbance of the hill during the cyclone of September 1880.

9. In 1889 Mr. Oldham, Geological Survey of India, was asked by the local government to give his opinion as to the subsidence along the Government House ridge on Sher-ka-banda and wrote...“ From the fact that there is a distinct line along which subsidence takes place, that a considerable part of the subsiding portion is rock and not soil cap.....I conclude that the movement takes place along some fault or fissure which runs at a considerable depth through the solid rock.” In the same year Mr. Henslowe Executive Engineer, referred to the fissure under Government House as being due to no movement of the soil cap, but to a distinct separation through the axis of the hill itself.

In a report dated 13th February 1895, Mr. F. O. Oertel, then District Engineer of Naini Tal, stated that, “the crack on the upper badminton court near St. Loe gorge has opened out again.....some cracks have also shown on the roads below Government House.

11. Early in 1895 the president of the municipal board drew attention to certain fissures and subsidences at the foot of the Ravenswood spur behind the Grand Hotel and the Allahabad Bank, and Col. Pulford R. E., Superintending Engineer, was asked to examine and report upon them.

12. In his report of the 21st March 1895 Col. Pulford wrote : “The cause of the cracks and settlement of the walls in the Allahabad Bank is

undoubtedly faulty construction of the foundations...nor has any provision been made for carrying off the water from a spring which issues from the hill at this point. Measures for remedying these defects are in progress and should, as far as I can judge, give satisfactory results. I inspected the whole of the Grand Hotel and the back walls and drains. I was quite unable to notice any of the alarming symptoms mentioned by the president of the municipality. In my opinion the hillside behind the Grand Hotel is so far in a satisfactory condition. I inspected the site of Ravenswood...the front portion of the site has sunk slightly, probably owing to the fact that it is made ground."

As regards remedial measures Col. Pulford referred to the recommendations of the 1880 committee and suggested that the municipal board be asked to report how far they had been carried out.

13. On the 28th May 1895 the president of the municipality submitted a report, the gist of which was as follows :

- 1st. That the board had spent about $1\frac{1}{2}$ lakhs of rupees on lining and revetting ravines between the years 1880 and 1895, and though much still remained to be done, they were not in a financial position to undertake it.
- 2nd. That the prohibition of gardens and the covering of terraces and platforms with clay had not been carried out owing to hostility of owners and change of executive.
- 3rd. That further erections of buildings had been permitted in certain cases but with expert advice, the opinion given being that a well drained house was better than a badly drained site.
- 4th. That a bye-law had been passed to deal with house drainage, but had not been fully enforced.
- 5th. That turfing and planting had been done where it appeared to be required ; that bye-laws to prohibit grazing had been made and enforced and that there had been frequent prosecutions for grazing in private compounds.
- 6th. That the remaining recommendations of the 1880 Committee had been enforced.

14. To the above report was appended an interesting letter dated May 1895 from Mr. Matthews, an old resident and house owner of Naini Tal, in which he reproduced his report to the committee of 1880. In this report Mr. Matthews writes : "My observations lead me to the conclusion that all the ravines on Sher-ka-danda are more liable to slip on their eastern sides than on their western." He then gives instan-

ces of many houses and sites, chiefly on the east side of ravines, which were cracked, and mentions Braeside in particular as having been built in 1846, and twice moved further east in 1872 and 1875

On the subject the old Government House hill, Mr. Matthews writes : " Between the 1880 landslip and the ravine to the west of Edgehill, the whole of the superincumbent soil appears disposed to slip off the underlying strata. I have seen numerous cases where such slips had begun years ago, large areas with trees growing on them having sunk and then stopped. If the numerous fissures are closed, pathways obliterated, and three or four drains built to collect surface water, this slip might perhaps be checked." Again he says : " It is noticeable here again that the fissures extending from Staffhouse down to Edgehill ravine indicate an intention of settlement to westward. The slip in the ravine nearest to Edgehill which caused destruction of some of its out houses, is also on the eastern bank, which has fallen westward."

Mr. Matthews gives his opinion as to cause of the 1880 slip as follows : " Tarahall, built in 1875, discharged through its gateway a large quantity of water which went through the Maldan estate, and shot down the cliff overhanging the Victoria Hotel. During 1875 to 1878 there were scanty monsoons, but in 1879 this drainage destroyed the road under Maldan. A quantity of water from under Staffhouse, the drainage of part of the Maldan estate, and probably the whole of the drainage of Tarahall and Brackenbury, discharged by this channel. I cannot pretend to say that the hidden springs too were not fed by the large plateau excavated from Tarahall and Brackenbury. Last year I noticed for the first time, a great stream of water rushing suddenly out of the ravine immediately to the east of Staffhouse, but the bulk of the water disappeared before it got to the mission premises in some mysterious way. This spout I at once attributed to Government House excavation, and the chances are, that the cracks now visible on the St. Loc estate, are attributable to the saturated Government House plateau." Mr. Matthews then describes the scour which had been going on in the Ravenswood ravine : he attributes the crack in Ravenswood to bad building ; between Ravenswood and Rajpur (above the Grand Hotel) he could see no fissures, though at Rajpur there were numerous fissures which he thought were undoubtedly connected with the ravine to the west.

15. In his letter of the 1st of May 1895, mentioned at the beginning of the last para, Mr. Matthews, in referring to his report of 1880, writes " Mr. Willcocks lined this ravine (the Edgehill ravine) from the mall above Edgehill downwards. For some reason he did not use lime in the middle portion of the masonry. A large volume of water may be seen appearing at the source of the spring and, unless in heavy rain, not a drop passes

the mission premises. I have been observing three settlements which began in 1880 and have gone on slowly increasing yearly since ; they all appear to have connection with each other and the last one is on the mall over the head of the Edgehill ravine." He attaches a map showing the position of these slips one above the other on the eastern bank of the Edgehill ravine.

With reference to the Ravenswood spur, he writes: "The discharge of the roadside drain in 1880 set in motion that part of Phoenix Lodge estate (now called Spring Cottage) which lies to the east of the ravine. Mr. Willcocks took off the water from the upper block of out houses by a masonry channel into the Ravenswood ravine. This is very badly crackedNotwithstanding these precautions the movement of the western part of Phoenix Lodge terrace has never entirely ceased, though it has not developed much in 12 years."

16. In April 1895, a committee, with Mr. J. S. Beresford as president, was appointed by the Lieut: Governor to consider the safety of the old Government House on Sher-ka-danda. This committee held the same opinion as that expressed in the report of 1883, viz. that the cracks in Government house were originally caused by the disturbance of September 1880. They observed with surprise that no action appeared to have been taken on the report of the 1883 committee.

They found that the angle of repose of dry slate shingle was 38° and that experience had shown, that the hills of Naini Tal, consisting of underlying slate with a soil cap of disintegrated shale, would stand well at angles of 35° to 40° where the surface drainage was attended to and the toe of the hills was not subject to erosion. They were of opinion that no immediate apprehension for the safety of the Sher-ka-danda hill need be felt on account of the existence of the crack along the Government House ridge, and were much struck by the beneficial results of the drainage improvements that were carried out on the Sher-ka-danda hill after the landslide of 1880.

They did not consider that Government House was structurally unsafe, but recommended certain protective measures among which were the following:

- (3) All roads and open spaces to a distance of 30 ft. from the building to be covered with a layer of 6 inches of well rammed limestone metal broken to $1\frac{1}{2}$ " gauge and mixed with 8% of clay, laid with a slope of 1 in 50 towards the drain.
- (10) The badminton ground at St. Loe Cottage site to be sloped off as nearly as possible to the original angle of the hill.
- (12) The tennis and badminton courts in St. Loe grounds to be covered with 9 inches of well rammed limestone, mixed

with 8% of clay, laid to a slope of 1 in 200 on the actual courts, and 1 in 100 outside this area ; the whole to be drained into suitable channels delivering into the nearest outfalls.

- (13) In order to test by actual observation from fixed outside points whether there was any movement in the hill below Government House, stations were selected from which points on Government House hill and one or more points on adjacent hills in the same vertical plane could be observed.
- (14) Pillars of masonry were built at selected points on both sides of the fissure along the Government House ridge for observing the differential movement.

17. Mr. Oldham, who was one of the members of the committee, in a separate note, proposed that an adit should be driven into the southern face of the hill at a point between 75 and 100 ft. directly below Government House and running back clear of the buildings. He argued that this was the only practical means of dealing with the cause of the mischief and that if the rocks could be kept permanently dry, or nearly so, nothing need be apprehended. Later however, in dissenting, from part of the report he wrote : "I now think it too late for an adit to do any good. This movement has been distinctly going on even during dry weather and I regard the danger to the site imminent." Commenting on this note, Mr. Beresford wrote : "In my opinion and in that of several members of the committee, the drainage effect of such an adit would be trifling, if any. The important point is to prevent water from entering the hill as far as possible."

18. Subsequently in a letter dated the 11th June 1895, giving his reasons for considering the site of old Government House unsafe, Mr. Oldham wrote : "These reasons.....may be said to be a comparison of my observations with the well established order of events which has been observed to precede a landslip on hills of a similar nature. Under such circumstances there is a general downhill movement of the disintegrated rock near the surface. At first this is ill defined, but after a certain stage has been reached, a definite line of weakness is established across the upper limit of the coming slip. At the same time lines of weakness, marking the lateral limits of the future landslip, are generally established down the slope of the hill. In the area so defined other minor fissures and deformations are found ; but as the whole hill is moving, they are not so conspicuous as where there is a well marked limit between the part which is moving and that which is comparatively stable. I believe that lateral lines of shear may be recognized in the ravine between St. Loe and Staffhouse

where the drain built in 1880 has been considerably deformed by numerous cracks, all of which show a transverse shearing of the drain as a whole. The transverse fissuring at the head of the future slip is however well marked ; my attention was drawn to it in 1889 when I reported that the matter was serious but need not be the cause of immediate apprehension. Had I then any suspicion of the rapid development which would take place in the next 5 years I should have used different language." As an appendix to his letter Mr. Oldham, quoting from Tcharner's work on land slips in Switzerland writes....."that the diversion of rain, spring, and snow water from hillsides where it sinks into the ground, is the best means of averting such calamities.....should fissures, subsidences etc. occur they cannot fail to be noticed by hunters, herdsmen or others who should give immediate notice of the same," and he continues : "as regards prevention Tcharner lays stress on the removal of in soaking water by wooden troughs or masonry drains."

19. In a note, dated the 21st June 1895, Mr. Beresford remarks on the above letter and deals with the whole question in a thoroughly practical manner.

In para 2 he describes the shaley soil cap of Sher-ka-danda as being entirely dependent for its stability on frictional conditions and says..... "The only disturbing influence is an excessive ingress of water and the pith of all remedial measures connected with the hill is facilitating the discharge of surface water."

In para 3, Mr. Beresford writes: "I gather from Mr. Oldham's letter that the idea of a general movement of the hillside is chiefly based on his observation of the crack along the ridge.....The evidence of the movement is a crack near the extreme summit of the hill which has been in existence for at least 15 years, the width of which is probably nowhere over 2 in. There are no records to show how much the crack has increased since 1889 but it seems rather a stretch of words to speak of rapid development. The local fissures referred to by Mr. Oldham are, I consider, no indication of a general movement of the hillside."

Again in para 4, he writes : "There can be no question that the drains constructed and the various precautions taken after the landslide of 1880, have much improved the condition of stability of the Sher-ka-danda hill. Less rain enters the soil cap now, as it is notorious that springs are less in volume."

20. In view of the disagreement of Mr. Oldham with other members of Mr. Beresford's committee, Mr. C. L. Griesbach, Director, Geological Survey of India, was asked to examine and report on the stability of Government House hill. Mr. Griesbach in a letter dated 30th June 1895, wrote as follows :

Para 3. ".....I fully agree with the opinion expressed by Mr. Oldham that there is considerable danger of landslips occurring on the slopes of Government House hill.

Para 4. Mr. Oldham considers that the danger is more or less imminent and bases this opinion on certain observations which he believes indicate a general movement along the surface of Sher-ka-danda,.....I consider however that this view is extremely difficult to prove though there is some probability that such general movement does exist which may be of the nature of a dislocation along the line now indicated by the crack on Government House hill. On the other hand I am not satisfied that the "shearing" which may be observed in the drainage channels has anything to do with such a general movement, if it exists at all. That may well be connected with ordinary earth pressure, in the same manner as the various cracks in the retaining walls or revetments along roads and behind houses. Such may indeed be the forerunners of minor slips and should be looked to, but I question whether they could be interpreted to be indications of the general movement hinted at."

21. In June 1895, Mr. H. S. Wildeblood, reporting on the way in which the recommendations of the 1880 committee had been carried out, wrote :

Para 6. The recommendations of the committee of 1880 seem on the whole to have been well carried out at the time under the superintendence of Mr. Willcocks, Executive Engineer.

Para 7. But the further improvements and protective works which were necessary, and the repairs of those carried out in 1881, seem not to have received the attention their importance deserved.

Mr. Wildeblood noticed that earth had been dug for road repairs in a reckless manner, that fallen breast walls required attention in many places, and that some ravines required to be lined with masonry.

He also noticed that numerous fissures required to be filled with clay, and instanced those above Rajpur.

In Para 24. He wrote : "In other places gardening has been allowed to a dangerous extent.....at Ravenswood there is an excess of terracing."

He remarked that several tennis courts and gardens had been made since the landslip of 1880.

22. In resolution No. 8, dated 9th of July 1895, the whole question of the stability of the Sher-ka-danda hill, and old Government House was reviewed.

The following are extracts from the concluding paragraphs :

Para 9. His Honour the Lieut. Governor.....is unable to accept the statement that a landslip on Sher-ka-danda hill endangering the safety of the Government House site is imminent.....The experience of the landslip of 1880 goes to prove that ample warning of an impending landslip is given by unmistakeable surface indications, and it is satisfactory to be able to assure all concerned that a close scrutiny of the hill has failed to bring to notice any sign whatever that danger of the kind is imminent.

Para 10. A careful examination has recently been made of the Sher-ka-danda hill and the results show that it is now in a far sounder condition than that described in the report of the committee of 1880.....The danger of landslips occurring from the cutting away of the sides of the ravines, by the drainage water to which the landslip of 1880 was mainly, if not entirely attributable, is now practically non-existent along all the main ravines owing to the excellence of the works carried out on the recommendation of the committee of 1880 ; and had the other measures, insisted on by that committee, been carefully attended to, there would in all probability, have been no occasion for the uneasiness now felt.

23. In a further Resolution No. 1939/xl—44B dated 10th of July 1895, issued in the municipal department the following passages occur :

Para 2.—It is essential, in the interests of the settlement, that measures should be adopted which will ensure for the future the strict observance of the recommendations of the committee of 1880. The Government regrets to find that owing to a variety of causes, these recommendations have in several respects been neglected by the municipal board, and that the works constructed after the landslip of 1880 have not been efficiently maintained.

Para 3.—The Lieutenant Governor has directed that a portion of the Sher-ka-danda hill lying, roughly speaking, between the club ravine on the west and the Ravenswood spur on the east, be transferred to the control of the P. W. D. which will arrange within those limits for the construction and maintenance of the public drains, roads, and revetment walls.

Para 4.—As regards gardens, it is obvious that terraces on which vegetables are grown, or roses etc planted in beds, are simply contrivances for catching the water; their abolition on the hill above referred to is imperatively called for. They should either be covered with well rammed clay, or the original slope of the hill should be restored ; grass, shrubs etc. being afterwards planted. The municipal board should be directed by the Commissioner to take immediate steps under their bye-laws to carry out this important reform.

Para. 6. The municipal board should examine the drainage and retaining walls on each private estate and should issue such orders as may be rendered necessary by the circumstances of each.

Para 7.—The Government will ask the Forest Department to undertake the duty of planting the hill sides.

24. We now come to Mr. T. H. Holland's report of 1896. He describes the geological structure of the hills, and states that experiments have shown that argillaceous rocks (the slates and shales of Naini Tal) are amongst the most absorbent of all rocks and that such absorption prepares the way for chemical action, which in its turn leads to destructive mechanical action. He explains that the action of water on the slates first produces expansion and consequent creep downwards, and prepares a slippery clay which reduces the co-efficient of friction. He shows that the average dip of the slates on Sher-ka-danda is 40° towards the W. S. W. whilst the direction of greatest slope of the hill under Government House is towards the S. W. and at the site of the landslip of 1880 towards the S. S. W. so that the apparent dip of the bed in the direction of the surface slope, is in fact $37\frac{1}{2}^{\circ}$ in the former, and 31° in the latter case, or approximately coincident with the surface slope at each place. He states that the more nearly this condition is reached the greater is the danger of sliding.

The report is accompanied by an excellent contour plan and numerous sections of the hills which show that under Government House and in the Revenswood spur, a considerable area of the hillside lies outside the 37° plane (the angle of repose of dry shale) and the steepest slopes are generally towards the foot of the hill, which indicates that a downward creep has been going on. He describes the premonitory symptoms of a landslip thus : " In every landslip there is an upper region (Abrissgebiet) in which the rocks are torn away from the rest of the hill ; a middle portion through which the materials move down ; and a lower portion in which the rubbish becomes heaped up. The commencement of a creep or slide is indicated by the development of certain characters especially in the upper and lower portions of the mass in motion. The first indications of a creep consist commonly of the cracking of the upper portion of the mass with depression of the soil below ; at the same time protuberances are gradually formed at the foot of the slope.....Longitudinal cracks limiting the moving mass laterally...extent for great distances...These lateral lines of shearing, which run down the hillside are much less marked than the transverse fissures above...The cracks formed in the upper portion are generally gaping and curved with the convexity upwards..."

Mr. Holland states that abundant warnings of the nature above described were given before the disastrous landslip of 1880, and points to the cracks in Braemar and St. Loe which occurred at the same time as indicating a movement towards the lake of the lower portion of the hill. He then refers to the depression on the eastern bank of the Edgehill ravine, between St. Loe and Staffhouse which was first noticed by Mr. Matthews as recorded in para 15 of this report. The depression appears in four

roads and follows the direction of dip of the strata. "No system of surface drainage," he adds, "is sufficient to remove the whole of the rain water which falls on a hill composed of such porous rocks as the slates of Naini Tal, and subterranean accumulations should be removed by adits." He describes minutely (paras 110 and 115) where such adits should be located to give the best results. After describing the Government House and Edgehill spur in detail, Mr. Holland writes: "As long as Edgehill and Ravenswood stand the hill under Government House is, I consider, absolutely safe."

25. *Protective Works.* The foregoing is a brief recapitulation of the essence of what has been written on the subject of the stability of Sher-ka-danda since the landslip of 1880; we now come to what has been actually done in the way of (1) protective works (2) observations.

26. Prior to the great landslip of 1880 the lower portion only of the Rosamond's well ravine, at the head of which the slip of 1867 occurred, had been lined and revetted. After the 1880 landslip the following 6 main ravines on Sher-ka-danda were lined with masonry and revetted under the superintendence of Mr. Willocks, Executive Engineer of the Public Works Department, at a cost of Rs. 2,11,579.

1. The Baranala or Club ravine.
2. The upper portion of Rosamond's well ravine (now known as the Poplars drain).
3. The ravines between Staffhouse and Edgehill.
4. The ravines east of Edgehill and St. Loe which cross the mall close to the Grand Hotel.
5. The Lakeview ravine.
6. The Melville Hall ravine.

27. Previous to the year 1895 all the public roads and drains were in charge of the municipality, but in accordance with G. O. No. 1936/XI 44B. dated 10/7/95 (*vide* para 23 above) Mr. H. S. Wildeblood, Executive Engineer P. W. D., was placed on special duty to carry out necessary protective work on Sher-ka-danda. The object of these works was to intercept by a proper system of drains all rain water falling on houses, terraces and roads, and convey it to the lake by masonry channels. As regards the roads on this hill the principle adopted was to give the surface a good slope inward and to construct a continuous masonry gutter along the inside edge discharging at intervals into masonry channels leading down the hill side. In the report of this estimate Mr. Wildeblood stated that observations made during the rains of 1895 shewed that in the natural state very little water flowed off the hill side of Sher-ka-danda and that roughly

speaking the only portions which threw off water were the drained terraces, roads and roofs.

28. The protective works carried out by Mr. Wildeblood in 1895-96 comprised over 6 miles of masonry drains on Sher-ka-danda and 3 miles of drains belonging to the Baranala system, besides improving and draining the roads on Sher-ka-danda and piercing some short adits to drain the interior of the hill. These works were completed at a cost of Rs. 91,892 and maintained through the rains of 1895 at an additional cost of Rs. 5,738.

29. In October 1896 the works were made over to the charge of the municipality with a note by Mr. Wildeblood in which he advised that :

- (1) Earth for repairs to roads should be taken from beyond the outside edge.
- (2) Breast walls should be renewed when failure to resist the earth thrust became apparent.
- (3) Gradual extension of the drainage system should be carried out.

30. During the progress of the works above referred to Mr. Wildeblood reporting on the subject of adits, wrote : "In some places at the foot of steep slopes where no springs appear on the surface, I have found on opening out the capsoil for 10 or 15 feet that an under ground spring flows down the hill.....It is not proposed to follow up the spring into the heart rock as this would be useless, the tunnels will only go so far as excavation can be carried out without blasting, the idea being merely to drain the capsoil and loose rock." In this opinion Mr. Wildeblood was supported by Mr. Oldham late Director of the Geological Survey who in his preface to Mr. Holland's report of 1896, wrote :—"For the prevention of landslips or settlement of the hill side it is only necessary to prevent the accumulation of water in the soil cap with which I include what would ordinarily be called solid rock, so far as it has been affected by chemical change and movements of the nature of those described in para. 91 of the report." The adits constructed by Mr. Wildeblood on this principle in 1896 were five in number and only tapped the cap soil, the longest near Spring Cottage being 32 ft. long*

* The five adits are :

- (1) one near Blythe Cottage (in the Club ravine)
- (2) one below Spring field
- (3) one near St. Loe ground below old Government House
- (4) one at Spring Cottage, east tunnel
- (5) one at Spring Cottage, west tunnel

The following are the discharges measured on the 11th August 1898 after 14.65 inches of rain on the 10th of August.

- | | | | | |
|-----|--------|---------|-----|--------|
| (1) | 13.28 | gallons | per | minute |
| (2) | 13.82 | " | " | " |
| (3) | 13.15 | " | " | " |
| (4) | 164.06 | " | " | " |
| (5) | 246.09 | " | " | " |

31. Incidentally it may be mentioned that in April 1896 three of the principal house owners of Naini Tal addressed the president of the municipal board, criticizing the works, Mr. Matthew's criticism covering many pages. Their chief objections were :—

- (1) That retaining walls had been underpinned to form inner drains and would fall down when water concentrated in the drains through spoil from the outer edge of the road washing in and obstructing them.
- (2) That large quantities of soil had been thrown out from adits etc, which would be washed into and block the main drains.
- (3) That new drainage had been taken into old drains, not big enough to carry it.

These objections were carefully considered by Government at the time and found to be, for the most part, groundless. After the rainy season of 1897 Mr. Wildeblood, who had completed the works, was able to point out how well they had stood the test of the unusually heavy rains.

32. In 1897 the rainfall of June to September amounted to 127 inches culminating in a fall of 13 inches on the 27th of September. In this downpour the Langdale and Endcliffe drains of Ayarpatha were completely wrecked, but beyond small slips behind Bankhouse and the Lake Hotel, there were no casualties on Sher-ka-danda.

In 1898 the heavy rain which fell on the 13th of August and the following days again destroyed the Langdale and Endcliffe drains which had just been rebuilt by the municipality, but Sher-ka-danda again escaped, except for some slight damage to the road by the overflow of the Maldon Cottage drain.

Upon this, the president of the municipality supported by the Commissioner, addressed Government with the request that the main drains in the settlement should all be taken charge of by the Public Works Department as the municipal staff had not the necessary professional knowledge.

33. In September 1898 the Public Works Department actually took over all public drains, excluding roadside gutters, but no definite instructions appear to have been given on the subject until April 1900 when the following Government order was issued. G. O. No. 1557 W/357, dated 21st April 1900.....Para. 2. "under the circumstances the Lieutenant Governor will sanction the repairs of all drains except private drains and roadside gutters being carried out by the Public Works Department, the cost, estimated at Rs. 5,000 annually..... being deposited by the municipality. No charge for establishment and

tools and plant will be made..... If this sum should prove insufficient the municipality will be asked to find any further sum required.....The responsibility of Government will be limited to making the best use of the amount available." Subsequently a list was prepared giving a description of all drains and their condition. This list was accompanied by an index map. In G. O. No. 1859 W/357, dated 17th June 1901 to the address of the Commissioner of Kumaon it was represented that the annual grant of Rs. 5,000 for the maintenance of the drains in charge of the Public Works Department had proved insufficient and in resolution No. 12, dated 17th July 1901, the municipal board raised the grant to Rs. 7,000 at which figure it still stands. In G. O. No. 4011W/357, dated 6th December 1901 it was ruled that all roadside drains receiving drainage from public feeder drains were to be placed in charge of the Public Works Department and that all other roadside drains or gutters were to remain in charge of the municipal board.

34. A statement of municipal protective works constructed by the municipality and the Public Works Department since the year 1898, accompanies this report (*vide* appendix A). This statement does not however include all the protective works carried out by the Public Works Department for in the two years 1898-99 and 1899-1900 alone over 80,000 rupees were spent on completing the Naini Tal drainage system, a work which the preceding heavy rains had shown to be necessary. In these two years a mile and a half of drains were added to the Sher-ka-danda or Baranala systems, 490 feet of drains were constructed on Ayarpatha; the Sukha Tal system of 7024 feet of drains and the Bull's Head system of 5856 feet were completed. The whole system of public drains in Naini Tal, not counting road side gutters and subsidiary drains from private estates nor the Ballia ravine, now makes up a length of over 22 miles. Experience has proved these drains to be of immense value in preventing erosion and saturation of the cap soil and the Committee consider that the careful maintenance and extension of these drains is the best means against landslips. An index map of the Naini Tal public drains corrected up to 1900 accompanies this report.

35. *Observations.*—The observations made to detect damage, movements etc., may be considered under three heads :—

1st.—General observations made during the year by the District Engineer in accordance with G. O. No. C. 1835BR, dated 15th July 1890, for the purpose of recording the results of all earthquakes and heavy rains in slips, changes and movements, cracks and rock falls etc.

2nd.—Measurement between pillars erected on each side of the great fissure along the Sher-ka-danda ridge.

3rd.—Theodolite observations from Jesmond Villa and Tonnochy's.

36. General observations. The Committee regrets to find that the book in which the observations made previous to 1897 were recorded, has not been preserved as a permanent record in the District Engineer's office. The report submitted annually to Government in accordance with para 1059 of the P. W. manual of orders which is compiled from these observations, is of necessity much condensed, it is therefore essential that the original note book should be carefully preserved.

The District Engineer's annual report contains a brief record of occurrences and observations affecting the stability of the hills, drains, roads etc. in the settlement and throughout the district, as also a note of the rainfall in Naini Tal and the discharge of water from the lake.

The following extracts from these reports regarding the Sher-ka-danda hill are of interest.

1890. Slight fissures appeared in August in the road just under the zig-zag up to Government House, in the road leading from the george to Government House, in the lawn tennis courts at St. Loe, and in the neighbourhood of Ravenswood.

Brachouse and Breaside cracked along the verandha and out on to the terrace on either side.

Tarahall back wall cracked.

The revetment behind Lawrie's studio advanced one inch.

The fissures below Government House were rammed with clay by the municipality.

1894. Cracks in St. Loe outhouses opened out.

1897. Small slips occurred behind Bankhouse and the Lake Hotel. (The heavy rains of 1897 caused damage to roads in the vicinity of Naini Tal amounting to 2½ lakhs of rupees).

1900. Tell tales put on a crack in the large retaining wall below the site of Government House showed hair cracks.

1901. Two large rocks rolled down on the mall from Rajpur outhouses. Many local movements were indicated by cracks in new tell tales of not more than $\frac{1}{4}$ inch. The greatest settlement occurred in St. Loe grounds where the new level pillars indicated a subsidence in the Edgehill drain depression of $1\frac{1}{2}$ inch more than the adjacent spurs. A slight increase occurred in the old cracks in the compound of Brachouse.

1902. Earthquake shocks on the 16th June caused slight settlement of the Sher-ka-danda slopes. The St. Loe depression drained by the Edgehill drain which was being rebuilt, settled 1 inch more than the adjacent spurs.

1904. A local movement of a piece of cap soil measuring about 30 feet by 40 feet was noticed behind Staffhouse.

Sher-ka-danda fissure. Some measurements of the annual movement of the great fissure running along the ridge of Sher-ka-danda through the grounds of St. Cloud and Snowview are given in appendix B. The pillars were built in 1895 after the Beresford committee (see para 16 above) but unfortunately the annual movements have not been regularly recorded. No entries exist for the years 1896 and 1897 and again for the years 1899 and 1900. The first year in which movements are recorded is 1898, the year of the great Kalekhan landslip above the brewery. Then come two years of moderate rainfall 1899 and 1900 during which no movements are recorded and then in 1901 the fissure opened out again. The year 1901 was one of exceptionally heavy rainfall and of exceptionally large movements on the Kalekhan or depot hill. From 1902 onwards there is a slight continuous movement which will be seen to correspond as near as can be to the amount of rainfall for the year (*vide* rain tables in appendix C). Thus in the years 1904 and 1906, when, the rainfall was heavy, there was a correspondingly large movement in the fissure.

It will be noticed that the opening of the fissure increases the further west one goes and is largest where the fissure passes out of the hill through the retaining wall west of Snowview. Going from east to west the total movement or opening out of the fissure during the last 12 years at the four pairs of observation pillars, where measurements were taken, amounts to 1.56," 1.36," 3.06" and 7.37 inches. The differential vertical movement is even less. The figures do not disclose any tendency for the movement to become worse and the Committee though unable to fully understand the cause of the movement are of opinion that the stability of the hill as a whole is not at present affected thereby. It is instructive to compare the movements of the Sher-ka-danda fissure with those of the master fissure over the "Abrissgebiet" or area of rupture on the Kalekhan hill, *vide* appendix K. In making this comparison it must be borne in mind that while the Kalekhan hill is continually being undermined by the cutting action of the Ballia ravine, the Sher-ka-danda has no such destructive agency at work and in some respects is improving constantly, by the debris washed down filling up the valley and supporting the slopes above.

Appendix B2 gives tables of settlement observed in the St. Loe grounds and along the depression east of the Edgehill ravine on the middle mall

referred to above in para. 24. No appreciable differential movement is recorded at either of these places during the last five years.

The Committee consider these results very re-assuring as they relate to a part of the Sher-ka-danda hill which has all along been known as particularly unstable. The importance of these conclusions is marred to some extent by the referring bench mark not being placed far enough away from the disturbed area and the Committee would suggest erecting another bench mark for these observations on top of the St. Loe george on the solid rock north of the george.

38. *Theodolite observations.* Certain stations on the Edgehill and Ravenswood spurs were observed with a theodolite since 1895 from points near Jesmond Villa and Tonnochy's with reference to a fixed station on Ayarpatha, see para 16 item (13) above. Up to 1902 the referring mark was a pole placed each year as nearly as possible in the same spot on the summit of Ayarpatha. In 1902 a masonry pillar was erected with an iron rod as the referring mark. The observations were made by the Survey Department and apparently discontinued after 1903. A copy of the observations made up to that year is attached to this report as appendix D. From this it will be seen that the greatest movement was observed after the rains of 1901, in which year the Kalekhan hill also shewed the greatest movements. It is a pity that no earthquake records are available to complete the picture of cause and effect exhibited by the rainfall tables and movement observations on Sher-ka-danda and Kallekhan attached to this report.

The District Engineer has taken a fresh set of readings with an ordinary 7" theodolite from Jesmond Villa and Tonnochy's in November 1907. His readings are given in the tables of appendix E. The first table compares this year's readings from Jesmond Villa with those of 1895 and shews that the apparent movements Ravenswood spur exceed those on the Edgehill spur. For the two stations on Ravenswood spur show a total movement during the last 12 years of 51 and 52 inches respectively, while the three pillars on the Edgehill spur moved 42", 44" and 36 inches in the same period in the direction of the lake. This it will be noticed is only about as much as is recorded for one day's maximum movement of some of the pillars on the Kalekhan hill (*vide* appendix I). Moreover it must be borne in mind that the actual differential movement of the points observed is not necessarily as great as the recorded movement, for an allowance must be made for a forward movement of the whole of the Sher-ka-danda hill which seems to have taken place, if one may judge so from the observed movements of the points beyond the disturbed area. For instance Oakopenings on top of the ridge shews a forward movement of 29 inches and the Ramsay hospital of 30 inches during the last 12 years. In the case of these two points it can hardly be argued that there was any appreciable slip movement.

The next table of appendix E gives the result of theodolite observations from Tonnochy's for the last seven years. These also appear to show that the whole of Sher-ka-danda has moved bodily forward from 9 to 17 inches during that period. The greatest movement was observed at Braeside. This is no doubt in great part accounted for by a sliding movement towards the ravine scoured out in 1867 at the top of which Braeside is situated. For the sake of comparison another table is given in appendix E shewing the movements observed from Jesmond Villa during the last seven years. The only station which appears in both these tables is the Ramsay hospital. The apparent movement of the Ramsay hospital during the last seven years as observed from Jesmond Villa is 20 inches and as observed from Tonnochy's 15 inches. As a result of a careful study of these theodolite observations the Committee consider that they appear to be liable to considerable error owing to want of a sufficiently delicate instrument, but as far as they go they seem to show that there has been a slight forward movement of the Edgell and Ravenswood spurs during the last 12 years. The Committee however consider that so long as these observations show no greater annual movement than they have hitherto done no apprehension need be felt for the safety of the spurs.

39. *Results of Committee's Inspection.* As mentioned in para 2, the Committee carefully examined the Sher-ka-danda hill. They ascertained what had been done in the way of protective works since the last committee met in 1895 and studied the records of observations made since that time.

40. In their examination of the hill they found the public drains and roadside gutters clean and generally in excellent order, but many private drains overgrown and choked with dirt.

41. The committee found that some of the platforms and terraces had not been covered with well rammed clay or other impervious material as recommended by previous committees and that in one place (near Staff-house) new garden terraces had recently been made.

42. They also noticed that all buildings were not provided with eaves gutters and masonry drains to the nearest ravine.

43. They consider, however, that the municipality under their existing bye-laws, cannot compel house-holders to make platforms and terraces impervious to water or to provide eaves gutters and drains, and that the Municipal Act I of 1900 as it stands, does not empower them to make such bye-laws.

44. The Committee considered that neither the site of old Government House nor the platforms and terraces in the St. Loe grounds are sufficiently impervious to water, and that the drainage of St. Loe is generally defective.

45. The Committee did not observe anything in the nature of a recent fissure in the hill side but they noticed certain cracks in retaining walls and old drains which, though not new had in some instances continued to open every year on being pointed up. In every case these cracks seemed to indicate a local settlement of the cap soil on a slope which had been cut into to make a road, or on the edge of one or other of the many ravines which had been deeply scoured before they were lined with masonry. In only one place did they find a crack in one of the new drains built since 1901. These latter drains are of dolomite stone laid in lime mortar, sunk-pointed with cement and designed to resist the earth thrusts. These drains are gradually replacing the older ones, and occurring as they do at frequent intervals, form an excellent index of movement ; for the slightest separation, such as would take place at the head of an impending landslip, could not fail to show as a crack in the rigid masonry of the drains.

46. They noticed that many pathways are still used as short-cuts up the hillside, but they consider that in many cases these are beneficial rather than otherwise, as they afford a means of examining the hillside and of detecting cracks or movements which could not be observed without them on the jungle covered slopes.

47. They also noticed many large trees hanging over at dangerous angles ; these were mostly in depressions where a subsidence had occurred, or on the edges of steep banks.

48. The Committee observed several revetment walls which require to be repaired or rebuilt, and certain places which require further revetting ; for instance the banks of the Poplar's ravine towards its head, where the so-called landslip of 1867 occurred.

49. A large area below the middle mall to the east of Ravenswood seemed to the Committee to be insufficiently drained and moreover the drainage of the hillside above this is carried along the middle mall for a considerable distance before being discharged into a ravine, which is objectionable.

50. The Committee noticed that two municipal water tanks in the Glenmore ravine discharge their overflow on the hillside instead of into the adjoining masonry drain.

51. The Committee consider that, with the exception of the few points noticed in the foregoing paragraphs, the recommendations of previous committees have been well carried out ; that the system of surface drainage of the Naini Tal basin has been improved year by year and that if the present policy is continued and the householders will realize their own interests and co-operate with the authorities, no great anxiety need be felt for the stability of the hills under ordinary circumstances.

52. The evidence of local residents goes to show that the volume of water which now issues in the form of springs near the toe of the Sher-kandanda hill is small compared with the water which used to issue before the masonry drains and road gutters were made. That the rain which falls on the hillsides is controlled and passed into the lake more efficiently now than was the case ten years ago, is proved by the following comparisons which are deduced from the records of rainfall and discharge from the lake sluices recorded by the District Engineer. In 1895 of a total rainfall of 98 inches 40% only was passed into the lake, whereas in 1906 with a somewhat similar rainfall of 99 inches no less than 78% was discharged into the lake, leaving only 22% to account for by percolation or evaporation. Again in 1900, with 70 inches of rain, 31% only was received in the lake as compared with 75% in 1905 when the rainfall was 72 inches.*

In years of heavy rainfall the percentage of water passing off the soil into the lake is naturally greater than when the rainfall is light and well distributed, but the Committee consider that when evaporation and absorption are taken into account the figures for recent years show a high state of efficiency.

Remedial Measures. The Committee are of opinion that the following measures are necessary to ensure the stability of the hills in ordinary times and to enable warning to be given of impending danger.

1st. That the responsibilities and duties of the Public Works Department and of the municipal board respectively should be clearly defined. As regards drains the extent of their respective charges has been laid down in the Government orders referred to in para 33 of this report but something more than this is required. Generally speaking the Committee consider that the Public Works Department should be responsible (a) for all public drains (b) for all protective works (other than road revetments) in the ravines containing public drains, and (c) for other large public protective works requiring professional knowledge, which should be specified in detail. The Public Works Department should also continue to make the observations referred to in para 37 and 38 of the report and generally to record the condition of the hill slopes, particularly during and after the rains. For the theodolite observations a special instrument should be obtained to ensure reliable readings.

2nd. That during the rains one or more Public Works subordinates should be employed for the sole purpose of patrolling and examining the hill slopes, roads and drains. They should be instructed to look out for fissures and other signs of movement and should report daily to the District Engineer.

* The calculations on which the above figures are based are given in appendix F. The discharge formulae used may not give absolutely correct results, but as the same formulae are used for all the years the comparative conclusions may be accepted.

3rd. That the District Engineer's annual report should be accompanied by statements showing the results of measurements of the fissures on Sher-ka-danda and the theodolite observations from the first year they were recorded and should also contain a note of all the protective works carried out during the year.

4th. That the municipal board should be invested with power to take up land for public roads and drains and to enforce the recommendations of the 1880 committee regarding the treatment of existing platforms and terraces, the drainage of roofs and grounds and any other measures which are considered necessary for the stability of the hill sides. In the case of Darjeeling special powers have been conferred on the municipality by the Darjeeling Municipal Act and somewhat similar powers are necessary for the Naini Tal municipality. This necessitates special legislation.

5th. That the platforms and terraces of old Government House and St. Loe, which are the property of Government, should be experimentally treated with a view to ascertaining the most efficient method of making them impervious to water, with due regard to cost.

6th. That when experiments have shown what is the most efficient method of treating terraces and platforms and when the Municipal Board have power to enforce such measures, a local committee should be appointed to visit every private estate on what is known as the "prohibited area" and to decide how the terraces and platforms on each estate are to be treated, and that the municipal board should then proceed to enforce the measures recommended by that committee.

7th. That the question of stopping gardens specially vegetable gardens which have to be dug up periodically within the "prohibited area" should also be considered by the local committee.

8th. That the municipal board should warn all house owners about the month of April of each year, to clean and repair eaves gutters and masonry drains; and that they should be empowered in the event of non-compliance to do it themselves and to recover the cost from the house owner.

9th. That the drainage of the St. Loe grounds should be thoroughly overhauled; in this connection the Committee would suggest that branch (f) of drain No. 18 might with advantage be extended through St. Loe to the upper mall where it would relieve a long stretch of road gutter.

10th. That the loose blocks of talus and landslip material above Dumdin should be frequently inspected and broken up or propped up where necessary. That no bajri digging or quarrying be allowed on Sher-ka-danda except with special sanction and under supervision.

11th. That special measures should be adopted for the better observation of the settlement on the eastern bank of the Edgell ravine referred to in paras. 24 and 37 above. The Committee would suggest the following measures :

- (a) that the existing pillars be supplemented so as to form three lines crossing the Edgell depression and extending well beyond its influence on either side. The levels of these pillar to be carefully read each year after the rains with reference to a fixed bench mark on the north side of the hill at St. Loe George. These levels should be taken by the District Engineer himself and the result embodied in his annual report.
- (b) that retaining walls of good masonry be built on the inner edge of the middle mall, and of the roads above it, extending beyond the influence of the depression on each side, and that careful measurements be kept of any cracks occurring in these walls.
- (c) that a wall be built from the upper mall down to the St. Loe private road along the centre of this depression, and that if cracks appear in this wall they be measured.
- (d) All tell tales put up for crack measurements on these and other walls should invariably be dated.

12th. That certain large trees which are leaning over so as to cause a drag on the soil near the edges of ravines and banks should be cut down ; they should if possible be induced to coppice, but the Committee consider that it is better they should be killed than that they should remain as they are now. Every tree to be cut down must be previously marked by a responsible officer.

13th. That the system of public drains and road side gutters should be gradually extended as found necessary and revetment walls constructed where the cap soil requires support.

14th. The Committee consider that drainage of the subsoil by adits is impracticable unless carried out on a very large scale the cost of which would be prohibitive. On the principle, however, that nothing should be left undone which may possibly be beneficial, they suggest that tunnels might be driven into the hill at certain selected spots, the first of which might be between the upper mall and the St. Loe private road as suggested by Mr. Holland in para 115 of his report of 1895. On this point however Mr. Holland's opinion should first be obtained.

II. OTHER PARTS OF THE SETTLEMENT.

54. *Cheenu.* Rock falls from Cheena have been all along a standing menace to the houses below it. As long ago as 1885 Mr. Henslowe, Executive Engineer, constructed terraces above the upper mall to catch the rocks and other debris falling from the steep face of the Cheena cliff. The system has proved very successful and together with the planting now being carried out by the Forest Department to keep the loose shale from sliding should prove a sufficient protection to this part of the settlement. The Committee consider that these measures are sound and at present sufficient. They noticed that the Cheena drains are in excellent order and the terraces carefully looked after.

55. In a letter of the 1st May 1895 Mr. Mathews mentioned fissures in a small jutting knoll attached to the eastern spur of Cheena to the west of Tonmnochy's and wrote, "there is no doubt that this knoll will collapse sooner or later, perhaps gradually or most likely suddenly." The Committee had not time to visit this spot but recommend that it should be examined by the District Engineer and steps taken, if found necessary, to prevent the fall of a large mass or to render such a fall harmless.

In his annual reports the District Engineer has noticed the following occurrences :

- 1896. A crack was observed on the crest of Cheena and surveyed. The portion of the crest of the hill in front of this crack, which consisted of large masses of dolomite bedded in shale, was removed by blasting in the following year.
- 1899. Some large rocks fell from the western end of the Cheena scarp into Oakpark compound.
- 1902. A rock weighing about 5 tons fell above Oakpark but was stopped by a barricade below the mall.
- 1905. On the 9th July some rocks rolled down Cheena, owing to the scouring of a ravine near the crest, and damaged the Staffordhouse and Jesmond Villa properties.
- 1906. On the 3rd August a mass of shale began to move above Jesmond Villa but spread out and did no damage. A very large rock slipped above the head of the most westerly of the Cheena drains but was fortunately stopped by a spur; it was subsequently broken up.

56. *Ayarpatha.* Down the spur under Pendennis some breast walls on the west side of drain No. 38 are badly cracked but no such cracks were observed in the drain itself; these cracks may be due to subsidence consequent on the excavation for the rising main from the water works.

As regards Eastlaggan the Committee have no remarks to make except that they consider that when the road from here to the flats is widened the picturesque rock known as Craig Ellachie should not be touched; the road can be widened on the outside without any difficulty.

III. KALEKHAN HILL AND BALLIA RAVINE.

57. The overflow from the Naini Tal lake passes down the Ballia ravine. Before the discharge was carefully regulated a great deal of scour used to take place in the ravine and heavy downpours in the rains were invariably followed by slips on the Kalekhan or depot hill, closing up the old cart road through the depot which was then the only approach to Naini Tal for wheeled traffic. Many of the depot buildings including the church and some barracks cracked so seriously that they had to be dismantled. For many years the Bleakhouse spur was the bug bear of Naini Tal communications until in the rains of 1899 it came down altogether carrying with it the house which gave it its name and blocking up the ravine below. Various proposals were made for re-opening communications including a tunnel through the heart of the Bleakhouse spur, but the cost was found to be so great, that it was determined to abandon that side altogether and construct a new cart road on the Manora hill opposite, closing the depot road for wheeled traffic altogether. A temporary bridle path was cut along the face of the Bleakhouse spur to communicate with the depot. This has stood fairly well, although slight settlements continue to take place in parts of it, of which observations are given in appendix G. Before 1899 the lake bridge and regulating boards were in charge of the municipality but after the slips of that year the Ballia ravine committee suggested that the charge of the sluices in the regulating bridge be transferred to the Public Works Department along with the control of the entire length of the Ballia from the sluices to the end of the ravine. After the transfer the lake bridge was reconstructed with proper regulators and the upper part of the ravine was lined with pacca guide walls. The protective measures however proved insufficient to arrest the movements on the Kalekhan hill. In 1890 further slips took place in which the Ballia bridge at the brewery was carried away. After the rains of 1891 Mr. Alexander, Superintending Engineer and Mr. Holme, Executive Engineer found the condition of the Kalekhan hill so serious that they thought it necessary to issue a warning to the brewery and other adjoining property holders of the danger threatening them in case of an extensive slip from the depot hill blocking up the ravine. Little notice was taken of the warning at the time but the events of the year 1898 fully justified it. The rains were unusually heavy that year* and much damage was done to the Naini Tal settlement and its approaches. Forty inches of rain fell between the 9th and 17th August resulting in several slips in the Ballia ravine. These carried away the brewery bridge

* In appendix L tables are given of the rainfall during the year 1898. The excessive fall during the week in August preceding the landslip should be noticed.

and culminated in the large slip of the 17th August covering part of the brewery and causing many deaths. A temporary lake was formed in the Ballia ravine behind the earthen barrier of the slip which was not swept away till the following year. The shattered appearance of the Kalekhan hill slopes below the military cemetery gave rise to apprehension of even greater disasters to follow. Mr. Middlemiss of the Geological Survey in his preliminary report of September 1898 described the situation as follows :—"Great as was the slip of the 17th, it came very near being a much greater catastrophe, for the area of the present slip is surrounded by a somewhat larger concentric area, which is bounded on its outer edge by a great master fissure averaging 6 feet throw. Within that larger surrounding area the hill slopes are fissured and rent apart in a most dangerous way, the zigzags of the cart road have been suddenly depressed in many places, and small slips within that area have occurred, all testifying to the "touch-and-go" condition in which the crust of this outer rent area was on the memorable 17th. According to evidence being collected by the engineers, it would also seem that this greatly cracked area from the 1st September to the 12th was still moving, from the fact that the cracks at certain observed points on the road zigzags were deepening and widening at the rate of sometimes $\frac{1}{2}$ inch a day. Rest appears to have been now attained (21st September) along with the practical cessation of the rains. The greatest interest centres in this outer greatly cracked area and much of the time at my disposal was spent upon it, endeavouring to come to some conclusion about it. My opinion, briefly expressed here, is that it will at a future time form a second landslip in the ordinary course of events that it will descend together in disjointed pieces, floating on a liquid substratum, in every way analogous to the slip of the 17th. But in order that this may happen, I am of opinion that it will require a somewhat heavier down-pour of rain than culminated in the last slip. So long as dry, cold weather prevails, so long I think, there need be no fear of a second slip of that kind: with moderate rain there will probably be slight subsidence, which will increase as the rain increases. Lastly exceedingly heavy rain (next monsoon or later) will start the whole mass flowing downhill. It is of importance to realize that when this threatened slip takes place, the direction that the greater part will take will be somewhat lower down the Ballia ravine than the last. Hence it will miss the resisting bank and hill spurs which turned the flowing mass of the slip of the 17th and led it eventually down the Ballia ravine. As a consequence it will not only overwhelm the site of the present brewery and tonga restaurant, but will spread across the gentle slopes there as far as or above the cart road lying under the Charta slopes. I need not dilate here on the consequent damage to property below that point, though I am of opinion that no very permanent lake could be formed in the Ballia by the damming back of the stream, and hence that no resulting floods of any great size would be likely to affect the lower part

of the valley down to Ranibagh and Kathgotham." As regards preventive measures Mr. Middlemiss goes on to say :—"It is unfortunately a patent truth that all ideas of preventive measures as regards the threatening slope must be abandoned. Such measures would cost more than the properties and interest at stake, and they would be of very doubtful efficacy now that matters have gone as far as they have, and in any case would only be palliative for a while. The question then arises as to what is to be done. I only feel myself here able to advise one thing—a precautionary measure only—I would recommend watching the hill-side with a theodolite in the same way that the Sher-ka-danda slopes have been watched."

58. In G. O. 3201W of 11000P-1898 these theodolite observations were ordered to be made fortnightly during the winter months, weekly from April and daily from the beginning of June till the end of the rains. The first observation in accordance with these orders was made on the 1st of April 1899 from a point on Bleakhouse spur where a shed has been kept erected over a fixed transit theodolite. The observations have been kept up carefully ever since and an abstract list of them will be found in appendix H attached to this report. Three lines of pillars on the Kalekhan hill are observed with the theodolite, the furthest pillar on each line being on the ridge beyond the disturbed area. Measurements of movement along the master fissure, mentioned by Mr. Middlemiss, are also taken between stout pegs driven above and below the fissure. A map accompanied this report shewing the position of the observation pillars and fissure measurements.

59. From the table of observed movements in appendix H it will be seen that the pillars C2 and D2 on the spur facing the brewery have moved most, shewing a total horizontal movement of 31·6 and 33·5 feet during the last 9 years and a vertical movement of 12·7 and 13·7 feet. The pillar immediately above these two, *viz.* B2, has only moved 4·7 and 2·7 feet in the same period, proving that the lower portion is slipping much faster than the upper portion. The larger part of this total movement took place in August and September 1901, a year of exceptionally heavy rain fall. The greatest movement on any one day is recorded on the 27th August 1901 when pillar B2 moved 3 ft. 7½ inches and D2 moved 4 ft. 6½ inches horizontally (*vide* appendix I). Some large movements were also observed in July and August 1889. Thus pillar C2 is recorded to have shifted horizontally 1 ft. 5½ inches on the 25th July, 2 ft. ½ inch on the 31st July and 1 ft. 8¼ inches on the 7th August 1899. In spite of these enormous movements the great slip which was to overwhelm the brewery, predicted by Mr. Middlemiss, has not yet taken place and there is hope that the gradual downward movement of the surface attended by small slips will relieve the stress without leading to a great catastrophe. The local authorities, civil and military, and the manager of the brewery are kept constantly informed

of the observed movements and a special warning is issued to the latter when the pillars are found to have shifted more than 3 inches in any one day.

60. It is interesting to notice that as in the case of the Sher-ka-danda observations some differential movement has also taken place in the pillars A1, B1, and C1 on the solid ridge beyond the disturbed area on the Kalekhan hill. These pillars can hardly have shifted through any settlement of the ridge itself on which they stand and one is tempted to ascribe the displacement to general movements taking place in the mountain range as a whole.

61. The cause of all the mischief on the Kalekhan hill is to be sought in the overflow of water from the Naini Tal lake rushing down the Ballia ravine and cutting away the toe of the slope. To check this the outflow from the lake is carefully regulated so as to discharge the water gradually and prevent a sudden rush down the ravine. The gauge reading at the lake bridge and the daily rain fall is reported to the District Engineer every morning during the rains and he, or in his absence the Executive Engineer, issues daily orders on the opening and closing of the sluices. There are five sluices, with openings 30 inches wide and 15 inches high, worked by screw regulators. The crest of the overflow is 3 feet 9 inches above the floor of the sluices but the water can be held up to a total height of 5 feet above the floor by means of boards let down in grooves on top of the over flow. As far as possible the water should never be allowed to flow over the crest, and during the rains the level of the lake should be kept a couple of feet below the crest to allow for a sudden rise during heavy rain. Towards the end of the rainy season the level of the lake may be gradually allowed to rise to within a foot of the crest and finally the sluices closed to insure a sufficient depth in the following hot weather. Should the water rise above the level of the crest of the overflow the boards may be let down. A plan of the sluices as reconstructed in 1903 will be found attached to the annual report on the condition of the hill slopes of that year.

62. In addition to the regulation of the overflow into the Ballia ravine, the P. W. D. have carried out extensive protective works. Since 1883 nearly a lakh of rupees have been spent on flooring and lining the upper part of the ravine and some of the drains leading into it,* not counting

* Expenditure on the Ballia ravine.

1883	...	Rs. 13,348
1884	...	2,692
1898	...	3,730
1899	...	680
1900	...	5,400
1901	...	2,000
1902	...	16,150
1903	...	40,672
1904	...	671
1905	...	4,855

TOTAL RS. ... 90,748

an annual grant of Rs. 5,000 for the maintenance of the lake sluices and the Ballia ravine. The condition of the Kalekhan hill is a subject which naturally interest the military authorities as on it depends the question of the retention of the depot at Naini Tal. The removal of the depot has often been suggested and would probably have been effected in 1902 had not the local government agreed to pay the cost of lining the Ballia ravine below the Kalekhan hill from provincial funds provided that the convalescent depot for British troops was retained there (*vide* G. O. No. 176/351—1W dated 15 January 1902). In accordance with this agreement large protective works were executed during the following two years and the lining of the Ballia ravine carried to a certain distance. An other estimate for Rs. 73,458 was sanctioned in February 1905 for further extension of the lining, but the work has not yet been taken in hand for want of funds. The Committee consider it essential for the protection of the Kalekhan hill that the lining of the Ballia ravine should be continued and hope that money may soon be available for the execution of the further work estimated for.

63. In conclusion the Committee would point out that the time at their disposal for the examination of the question forming the object matter of this report was limited but they are unanimously of opinion that their examination was sufficient to show that under ordinary conditions apprehension need not be felt at present for the safety of the Sher-ka-danda hill and that although movements are no doubt going on, if the above measures are accepted, timely warning will be given of any impending danger. However to ensure that the protective measures will be properly carried out and that a careful watch is kept, the Committee would suggest that the condition of the hillsides be regularly reported on by a special committee at intervals of not more than three years.

C. H. BERTHOUD.

A. C. POLWHELE.

F. O. OERTEL.

A. B. GALE.

A. PERKS.

15th December 1907.

APPENDIX A.

Statement of Municipal protective works in Naini Tal from 1896 to 1907.

Year.	WORK CARRIED OUT BY MUNICIPALITY.					WORKS DONE BY P. W. D. FOR BOARD.	
	Cost Rs.	Description.				Cost Rs.	Description.
1896-97	1,066 1,545 190 772 442	Masonry lining Cheena ravine Protective works on Eastlaggan Catchment terrace above Oakpark Breast wall on Tonnochy road Repairs to Endcliffe drain					
	4,015	...	...	...	...	3,000	Repairs to drains.
1897-98	1,400 3,975 1,275 1,800 1,521 750	Fairlyhall drain Endcliffe drain Langdale drain Two drains near Oakpark Revetment wall near Brinsop Catchment terrace above Oakpark					
	10,521						
1898-99	nil	nil				nil	
1899-00	1,441	Repairs to public drains on Cheena				7,000	Repairs to drains.
1900-01	1,327 4,162	Catchment terrace above Oakpark Constructing Fairlyhall and Longview drain				7,000	do.
	5489						
1901-02	...	...	...	...	...	4,403	Constructing Goorkha barrack drain.
	...	...	...	...	...	8,670	Repairs to drain.
						13,073	
1902-03	328 529 636	Revetment walls above Oakpark and underpinning rock near top of Cheena.					
	1,136 908 303	Revetment walls below Pineyview Revetment walls above Bankhouse at bottom of Ravenswood spur.				7,000 1,170	Repairs to drains. Revetment wall below Braemar.
	3,840					8,170	
1903-04	...	...	...	...	...	2,145	Breast wall on Sher-ka- danda.
	226 171	Protective works above Oakpark Protective wall above Bankhouse				7,000	Repairs to drains.
	397					9,145	
1904-05	896	This amount was spent on supporting stones on Ayurpatha below Eastlaggan and Edwinstowe				7,000	Repairs to drains.
1905-06	...	...	...	...	...	7,000	do.
1906-07	...	...	...	...	...	7,000	do.
1907-08	...	...	...	...	...	7,000	do.
TOTAL ...	Rs. 26,599	TOTAL ...				Rs. 75,388	

APPENDIX B 1.

Measurements of large fissure along Sher-ka-danda ridge.

NOTE :—Pillars AB and CD are on Durga Sah's tennis Court.

E and F at St. Cloud

G and H at Snow View

AB and C D were originally 10 feet apart

E F and G H „ „ 16 feet „

In the following table H stands for the horizontal measurement taken with a steel tape. The original distance apart, viz 10 feet for pillars AB and CD and 16 feet for pillars E and F and G H is omitted from the table. Only the total horizontal movement is given for each year from 1895 onwards. The vertical movement V is read with a level in decimals of an inch and it is presumed that each pair of pillars were originally made level.

Pillars.		1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	Total move- since 1895
A B	H	10'			0.2"			1.02"	1.06"	1.06"	1.37"	1.37"	1.56"	1.56"	H=1.56"
	V	.00'						.13'	.16'	.16'	.17'	.19'	.22'	.22'	V=2.64
C D	H	10'			0.4"			0.93"	1.0"	1.0"	1.20"	1.20"	1.30"	1.36"	H=1.36"
	V	.00'	record.	record.		record.	record.	.12'	.14'	.14'	.15'	.15'	.18'	.18'	V=2.16
E F	H	16'	No	No	0.52"	No	No	1.96"	2.08"	2.08"	2.37"	2.75"	3.00"	3.06"	H=3.06"
	V	.00'						.08'	.10'	.10'	.09'	.11'	.12'	.13'	V=1.56
G H	H	16'			0.56"			2.50"	2.78"	3.00"	6.63"	6.87"	7.25"	7.37"	H=7.37"
	V	.00'						.29'	.31'	.33'	.36'	.38'	.43'	.46'	V=5.52

Records have also been kept of the difference in level of pillars A and C but no difference has taken place between them since 1901. Similarly pillars D and J show a $\frac{1}{2}$ inch difference of level during the last 6 years, while pillars B and I show a difference $1\frac{1}{2}$ inches in the same period. The pillars I and J are on Durga Sah's tennis court.

Statement of movement in the pillars on the St. Loe depression.

Number of pegs.		R. L. 1903	R. L. 1904	R. L. 1905	R. L. 1906	R. L. 1907	Total move- in. ft
Step	...	40.96	40.96	40.96	40.96	40.96	.....
Peg	1 ...	00.08	00.07	00.08	9.85	9.84	0.24
"	2 ...	9.94	9.93	9.94	9.82	9.91	0.03
"	3 ...	9.96	9.95	9.96	9.91	10.01	0.05
"	4 ...	00.00	9.99	00.00	9.95	10.07	0.07

Statement of movement in the pillars on the Edgehill ravine depression.

Step of drain.		00.49	00.49	00.49	00.49	11.49	.....
Peg	1 ...	00.00	00.00	00.00	10.00	9.97	0.04
"	2 ...	00.02	00.02	00.02	10.01	9.89	0.13
"	3 ...	00.00	00.00	00.00	9.96	9.93	0.07
"	4 ...	00.00	00.00	00.00	10.02	10.02	0.02

APPENDIX C.

Table of monthly rainfall in inches in Naini Tal taken from the District Engineer's rain gauge readings.

MONTH.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
January	10.13	4.86	...	...	1.87	0.09	1.95	6.98	9.34	...	2.69	2.33	7.34	1.79	2.80
February	10.38	2.12	...	...	2.42	10.27	2.50	2.50	4.09	1.88	0.81	0.17	5.16	10.87	6.98
March	5.09	4.67	...	...	2.68	0.05	...	0.46	1.78	0.17	1.54	3.40	3.56	0.99	5.67
April	4.09	...	...	...	0.20	0.50	2.13	3.29	0.28	1.02	1.06	0.24	0.28	0.51	2.70
May	3.52	1.70	...	...	1.14	1.22	2.43	2.43	1.14	1.67	2.75	4.47	2.80	1.29	10.81
June	21.43	21.19	29.38	31.39	10.65	19.89	20.36	8.18	3.25	4.74	2.62	12.90	7.31	14.44	3.76
July	38.67	26.42	28.84	15.82	52.97	22.32	41.41	30.53	30.41	31.85	15.75	33.47	34.29	26.82	19.04
August	20.03	29.62	34.12	21.73	29.74	52.27	11.91	25.81	57.12	35.28	22.03	28.37	27.24	46.95	18.06
September	23.24	19.02	5.27	0.45	34.07	11.88	2.42	11.59	9.43	10.02	11.94	18.13	9.40	14.17	0.41
October	27.74	...	...	0.08	0.30	...	0.44	1.29	1.54	6.72	0.37	...	1.20	...
November	0.79	...	...	...	1.43	...	...	...	...	...	3.94	...	...	...
December	0.85	...	...	...	3.94	...	3.22	1.65	...	0.10	1.59	1.22	0.72	...

APPENDIX E.

Theodolite observations on Sher-ka-danda hill.

Observations from Jesmond Villa shewing total movements from 1895 to 1907.

Station observed.	Distance of station in feet.	Reading in 1895.	Reading in 1907 by District Engineer.	DIFFERENTIAL MOVEMENT OF LAST 7 YRS.	
				In seconds.	In inches.
Ayarpatha ...	...	Zero	Zero	...	...
Pillar 5, Edgehill ...	4860	296°-40-02	296°-42-30	148	...
" 6 do. ...	4740	299°-25-39	299°-28-20	161	...
" 7 do. ...	4710	301°-56-20	301°-58-30	130	...
Outhouses above Ravenswood ...	5670	299°-25-41	299°-28-20	159	...
Pillar 8, Ravenswood ...	5970	302°-36-04	302°-38-30	146	...
Oakopenings ...	7380	296°-40-02	296°-41-10	68	...
Ramsay Hospital spire ...	8850	*315°-54-05	315°-55-00	55	...

* There is no reading of this station for 1895, so the nearest reading for 1898 has been used.

Observations from Tonnochy's shewing total movements from 1900 to 1907.

Stations observed.	Distance of station in feet.	Reading in 1900.	Reading in 1907 by District Engineer.	DIFFERENTIAL MOVEMENT OF LAST 7 YRS.	
				In second.	In inch.
Ayarpatha ...	...	Zero	Zero	...	...
Alma Cottage outhouses ...	960	300°-29-10	300°-31-50	160	...
Pillar 1, Snowview ...	1507	282°-57-00	282°-59-00	120	...
Braeside, lower outhouses...	1447	298°-26-50	298°-29-00	130	...
Pillar 4, Braeside ...	1500	300°-29-42	300°-33-00	198	...
Pillar 2, old Government House ...	3120	282°-56-45	282°-58-00	75	...
Ramsay Hospital spire ...	7590	306°-42-17	306°-42-50	33	...

Observations from Jesmond Villa shewing total movements from 1900 to 1907.

Station observed.	Distance of station in feet.	Reading in 1900.	Reading in 1907 by District Engineer.	DIFFERENTIAL MOVEMENT OF LAST 7 YRS.	
				In seconds.	In inches.
Ayarpatha ...	...	Zero	Zero	...	...
Pillar 5 Edgehill ...	4860	296°-40-12	296°-42-30	138	...
" 6 do. ...	4740	299°-26-15	299°-28-20	125	...
" 7 do. ...	4710	301°-56-30	301°-58-30	120	...
Outhouses above Ravenswood ...	5670	299°-26-12	299°-28-20	128	...
Pillar 8 Ravenswood ...	5970	302°-36-33	302°-38-30	117	...
Oakopenings ...	7380	296°-40-10	296°-41-10	60	...
Ramsay Hospital spire ...	8850	315°-54-20	315°-55-00	40	...

APPENDIX F.

Calculation of rainfall.

The whole drainage area of the Naini Tal valley is 1.9 square miles. One inch of rain on this area is equal to $\frac{1.9 \times 5280^2}{12} = 4.42$ millions of cubic feet. The discharge from the sluices has been taken from the annual reports. It is calculated from the formula $59w\sqrt{2gh}$. Where w = area of sluice opening. A table for this calculation is printed in the annual report for the year 1895. The discharge for 1897 is not known, as a lot of water escaped over the road into the Ballia ravine.

The lake overflow discharge is calculated from the formula $G = m L H \sqrt{2gh}$.

Where $m = 4$, $L = 8$, H = Head in feet. This table has not yet been printed.

	Annual Rainfall to 1st June in inches.	Discharge in millions of cubic feet.	Rainfall in millions.	Discharge absorbed &c. in millions.	Discharge per inch of rain. in millions c. ft.	Percentage of rainfall discharged by drains.
1895	97.60	188	431	243	1.92	.44
1896	69.55	82	307	225	1.18	.27
1897	127.43	...	...	...	...	...
1898	101.85	245	450	205	2.40	.55
1899	68.32	120	302	182	1.76	.40
1900	70.42	103	311	208	1.46	.33
1901	96.35	219	425	206	2.27	.51
1902	80.92	129	357	228	1.59	.36
1903	58.84	70	260	190	1.19	.27
1904	87.98	261	388	127	2.97	.67
1905	72.50	238	320	82	3.28	.75
1906	99.51	343	439	96	3.45	.78

Comparative statement of rainfall and discharges from lake bridge arranged according to amount of rainfall.

	Annual rainfall in inches	Discharge in millions of cubic feet.	Discharge per inch of rain.	Percentage of rainfall discharged by drains.
1903	58.84	70	1.19	.27
1909	68.32	120	1.76	.40
1906	69.55	82	1.18	.27
1900	70.42	103	1.46	.33
1905	72.50	238	3.28	.75
1902	80.92	129	1.59	.36
1904	87.98	261	2.97	.67
1901	96.35	219	2.27	.51
1897	97.60	188	1.92	.44
1906	99.51	343	3.46	.78
1898	101.85	245	2.40	.55

APPENDIX G.

Subsidence on the Depot Road (at mile 1.4226' of the old Barrielly Ranibagh and Naini T. trunk road.)

NOTE.—This subsidence dates from many years back but was not observed before did not exceed an inch in 1900. The movement started again on the 17th August 1901. Total subsidence to that date probably exceeded 3 feet. It extends over a length of chains of the road. No observations were recorded prior to 15th August 1901.

— 20 —

Statement showing annual movements of pegs.

[illegible]

APPENDIX H.

tract of annual movements in pillars on Kalekhan hill observed by theodolite from Bleakhouse spur.

(1) Horizontal movements.

	1899	1900	1901	1902	1903	1904	1905	1906	1907	Total to date.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	feet.	feet.	feet.	feet.
	...	...	...	...	...	...	...	0.70	...	0.7
	0 10 $\frac{1}{4}$	0 8 $\frac{1}{4}$	5 8	0 2 $\frac{3}{4}$	0 5 $\frac{1}{2}$	...	...	1.60	...	9.5
	1 9	0 9 $\frac{1}{2}$	4 0 $\frac{1}{4}$	0 6	0 4	0 8	...	1.20	...	9.3
	...	...	...	...	...	...	...	1.35	...	1.4
	0 6	0 1 $\frac{1}{2}$	2 6 $\frac{1}{4}$	0 3	...	...	0.3	1.00	...	4.7
	1 7 $\frac{3}{4}$	0 7 $\frac{3}{4}$	3 7 $\frac{1}{4}$	0 8	0 6	0 8	...	1.40	...	9.2
	...	...	...	...	...	...	...	1.20	...	1.2
	6 9 $\frac{1}{4}$	2 0 $\frac{3}{4}$	17 4 $\frac{1}{4}$	0 11 $\frac{3}{4}$	0 3	...	...	4.10	...	31.6
	1 10 $\frac{1}{2}$	0 9 $\frac{3}{4}$	3 7 $\frac{1}{4}$	0 8 $\frac{3}{4}$	0 3 $\frac{1}{2}$	0 3 $\frac{1}{4}$	...	1.10	0.1	8.8
	5 3	1 10 $\frac{1}{2}$	20 10 $\frac{1}{2}$	1 3	0 3	...	...	3.95	...	33.5

(2) Vertical Movements.

	1899	1900	1901	1902	1903	1904	1905	1906	1907	Total to date.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	feet.	feet.	feet.	feet.

	1 3	0 9 $\frac{1}{2}$	7 2 $\frac{3}{4}$	...	0 8 $\frac{1}{4}$	0 0 $\frac{1}{4}$	...	0.35	...	10.3
	1 3 $\frac{1}{4}$	0 0 $\frac{1}{2}$	3 7 $\frac{1}{2}$	0 6	0 4	0 2	...	0.40	...	6.3

	0 1 $\frac{1}{2}$	0 6	1 10 $\frac{1}{4}$	...	0 3	...	...	...	...	2.7
	1 0 $\frac{1}{4}$	0 6 $\frac{1}{2}$	2 8	0 4	0 2	0 3 $\frac{3}{4}$	...	0.30	...	5.3

	2 6 $\frac{1}{2}$	1 1	7 9 $\frac{1}{4}$	0 3	...	...	...	1.05	...	12.7
	1 0 $\frac{1}{2}$	0 5 $\frac{1}{4}$	2 8 $\frac{1}{2}$	0 1 $\frac{1}{4}$	...	...	...	...	0.1	4.4
	2 9	1 3	7 8 $\frac{1}{4}$	0 9	0 3	...	...	1.05	...	13.7

APPENDIX I.

Movements of pillars observed on *Kalekhan Hill* in August and September 1901.
(H=horizontal, and V=vertical.)

Date 1901.	Rain fall.	A2.		A3.		B2.		B3.		C2.		C3.		D2.	
		H.	V.	H.	V.	H.	V.	H.	V.	H.	V.	H.	V.	H.	V.
		ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
August.															
23	0 2	...	...	...	0 1 $\frac{7}{8}$	1 $\frac{7}{8}$	1 2 $\frac{1}{2}$	0 2 $\frac{7}{8}$	0 1 $\frac{7}{8}$	0 1 $\frac{7}{8}$	1 6 $\frac{1}{4}$	0 6 $\frac{1}{8}$
24	...	0 2 $\frac{3}{4}$	0 5 $\frac{7}{8}$	0 2	0 2	...	...	0 1 $\frac{7}{8}$	0 1 $\frac{7}{8}$	0 8 $\frac{3}{4}$	0 8 $\frac{3}{4}$	0 3 $\frac{5}{8}$	0 1 $\frac{5}{8}$	1 3 $\frac{1}{8}$	0 9 $\frac{1}{8}$
25	...	0 10 $\frac{3}{8}$	0 10 $\frac{3}{8}$	0 2	0 3 $\frac{7}{8}$	...	...	0 1 $\frac{7}{8}$	0 3 $\frac{3}{4}$	2 1	0 11 $\frac{3}{8}$	0 3 $\frac{5}{8}$	0 3 $\frac{5}{8}$	3 3 $\frac{3}{8}$	0 9 $\frac{1}{8}$
26	...	No observations taken on account of mist.													
27	...	0 8 $\frac{1}{8}$	1 4 $\frac{1}{4}$	0 3 $\frac{7}{8}$	0 5 $\frac{1}{4}$	...	...	0 1 $\frac{7}{8}$	0 5 $\frac{5}{8}$	3 7 $\frac{1}{2}$	1 8 $\frac{1}{4}$	0 7 $\frac{1}{4}$	0 3 $\frac{5}{8}$	4 6 $\frac{1}{2}$	2 0 $\frac{1}{4}$
28	...	No observations taken on account of mist.													
29	...	0 10 $\frac{7}{8}$	0 10 $\frac{7}{8}$	0 7 $\frac{1}{4}$	0 3 $\frac{3}{4}$	0 5	0 6 $\frac{1}{8}$	0 9 $\frac{3}{8}$	0 7 $\frac{1}{2}$	2 5	0 8 $\frac{3}{4}$	0 7 $\frac{1}{4}$	0 3 $\frac{5}{8}$	2 3 $\frac{1}{2}$	1 0 $\frac{1}{4}$
30	...	0 8 $\frac{1}{8}$	0 10 $\frac{7}{8}$	0 5 $\frac{3}{4}$	0 3 $\frac{3}{4}$	0 6 $\frac{1}{8}$	0 3	0 1 $\frac{7}{8}$	...	1 5 $\frac{3}{8}$	0 8 $\frac{3}{4}$	0 1 $\frac{3}{4}$	...	1 6 $\frac{1}{4}$	0 3
31	...	0 5 $\frac{3}{8}$	0 8 $\frac{1}{8}$	0 2	0 3 $\frac{3}{8}$	0 6 $\frac{1}{8}$	0 3	0 1 $\frac{7}{8}$	...	0 11 $\frac{1}{2}$	0 8 $\frac{3}{4}$	...	0 3 $\frac{5}{8}$	1 9 $\frac{1}{4}$	0 9 $\frac{1}{4}$
September.															
1	...	0 2 $\frac{3}{4}$	0 5 $\frac{3}{8}$	0 3 $\frac{7}{8}$	0 3 $\frac{7}{8}$	...	...	0 1 $\frac{7}{8}$	...	0 8 $\frac{3}{4}$	0 2 $\frac{7}{8}$	0 1 $\frac{3}{4}$	0 1 $\frac{3}{4}$	1 3 $\frac{1}{2}$	0 3
2	...	0 2 $\frac{3}{4}$	0 2 $\frac{3}{4}$	0 2	0 2	...	...	...	...	0 11 $\frac{1}{2}$	0 5 $\frac{3}{8}$	0 7 $\frac{1}{4}$	...	1 0 $\frac{1}{8}$	0 6 $\frac{1}{8}$
3	...	0 2 $\frac{3}{4}$	0 5 $\frac{3}{8}$	0 2	0 2	...	...	0 1 $\frac{7}{8}$	0 1 $\frac{7}{8}$	0 8 $\frac{3}{4}$	0 2 $\frac{7}{8}$	0 3 $\frac{5}{8}$	0 1 $\frac{3}{4}$	0 9 $\frac{1}{8}$	...
4	0 3	0 3	0 1 $\frac{7}{8}$	0 1 $\frac{7}{8}$	0 2 $\frac{7}{8}$	...	...	0 1 $\frac{3}{4}$	0 3	...
5	...	0 2 $\frac{3}{4}$	...	...	...	...	...	...	...	...	...	...	0 1 $\frac{3}{4}$	0 3	...

APPENDIX K.

Abstract of annual movements along master fissure on Kalekhan hill measured between pegs.

Horizontal movements.

Years of pegs.	1899	1900	1901	1902	1903	1904	1905	1906	1907	Total movement to date.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
No. 1 ...	0 8 $\frac{1}{4}$	0 3 $\frac{3}{4}$	1 10 $\frac{3}{4}$	0 2 $\frac{1}{4}$	...	0 1 $\frac{1}{2}$	0 1 $\frac{3}{4}$	0 4 $\frac{1}{2}$	0 0 $\frac{3}{4}$	3 7 $\frac{1}{2}$
" 2 ...	0 5	0 1 $\frac{1}{4}$	1 8	0 1 $\frac{3}{4}$	...	0 0 $\frac{1}{2}$	0 1	0 3 $\frac{1}{4}$	0 0 $\frac{1}{4}$	2 9
" 3 ...	1 3 $\frac{1}{2}$	0 3 $\frac{3}{4}$	2 2 $\frac{3}{4}$	0 1 $\frac{3}{4}$	...	0 0 $\frac{3}{4}$	0 1 $\frac{3}{4}$	0 6 $\frac{1}{4}$	0 0 $\frac{1}{4}$	4 8 $\frac{3}{4}$
" 4 ...	2 4 $\frac{3}{4}$	0 4 $\frac{1}{4}$	3 1 $\frac{1}{4}$	0 2 $\frac{1}{2}$	...	0 2	0 0 $\frac{3}{4}$	0 7 $\frac{3}{4}$	0 1 $\frac{3}{4}$	7 1
" 5 ...	0 0 $\frac{1}{2}$	0 2 $\frac{1}{2}$	0 6 $\frac{1}{2}$	0 0 $\frac{3}{4}$	0 0 $\frac{1}{4}$	0 0 $\frac{1}{2}$	...	...	0 0 $\frac{1}{2}$	0 11 $\frac{1}{2}$
" 6 ...	0 1 $\frac{1}{4}$	0 0 $\frac{1}{4}$	0 1 $\frac{3}{4}$	...	...	...	0 1	0 0 $\frac{1}{4}$	...	0 4 $\frac{1}{2}$
" 7 ...	0 5	0 2	1 6	0 1	0 0 $\frac{1}{2}$	0 1 $\frac{1}{2}$	0 1 $\frac{1}{4}$	0 4 $\frac{1}{2}$	0 0 $\frac{1}{4}$	2 10
" 8 ...	0 2 $\frac{1}{4}$	0 1	0 9 $\frac{1}{4}$	0 0 $\frac{3}{4}$	0 0 $\frac{1}{2}$	0 0 $\frac{3}{4}$	0 1	0 2 $\frac{3}{4}$	0 0 $\frac{1}{2}$	1 6 $\frac{3}{4}$
" 9 ...	0 6 $\frac{1}{2}$	0 3 $\frac{1}{4}$	1 2 $\frac{3}{4}$	0 3 $\frac{1}{4}$	0 0 $\frac{1}{2}$	0 0 $\frac{1}{2}$	0 1 $\frac{3}{4}$	0 3 $\frac{3}{4}$	0 2 $\frac{3}{4}$	3 1
" 10 ...	0 11 $\frac{3}{4}$	0 2 $\frac{1}{2}$	1 8	...	...	...	...	...	...	2 10 $\frac{1}{4}$
" 11 ...	0 5 $\frac{1}{2}$	0 0 $\frac{3}{4}$	1 6 $\frac{3}{4}$	0 0 $\frac{1}{2}$	...	...	...	0 1 $\frac{1}{2}$	0 1 $\frac{1}{4}$	2 4 $\frac{1}{4}$
" 12 ...	...	...	0 0 $\frac{1}{2}$	0 0 $\frac{1}{4}$	0 0 $\frac{1}{4}$	...	0 0 $\frac{1}{4}$	...	0 0 $\frac{3}{4}$	0 2
" 13 ...	...	...	0 2 $\frac{1}{4}$	...	...	...	0 0 $\frac{1}{2}$	...	0 0 $\frac{1}{2}$	0 3 $\frac{1}{4}$

Vertical movements.

Years of pegs.	1899	1900	1901	1902	1903	1904	1905	1906	1907	Total movement to date.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
No. 1 ...	0 9	0 2 $\frac{1}{2}$	1 11 $\frac{1}{4}$	0 2	...	0 1 $\frac{1}{2}$	0 1 $\frac{3}{4}$	0 5	0 0 $\frac{1}{2}$	3 9 $\frac{1}{2}$
" 2 ...	0 10	0 2	2 6 $\frac{1}{4}$	0 1 $\frac{1}{2}$	...	...	0 0 $\frac{1}{4}$	0 5 $\frac{1}{4}$	0 0 $\frac{1}{4}$	4 1 $\frac{1}{2}$
" 3 ...	1 2 $\frac{3}{4}$	0 4 $\frac{1}{4}$	1 5 $\frac{1}{4}$	0 3 $\frac{1}{4}$	...	0 1	0 1 $\frac{3}{4}$	0 8 $\frac{3}{4}$	0 0 $\frac{1}{4}$	4 3 $\frac{1}{4}$
" 4 ...	2 1 $\frac{3}{4}$	0 5 $\frac{1}{2}$	3 3 $\frac{1}{2}$	0 3 $\frac{1}{2}$	...	0 2 $\frac{1}{4}$	0 2 $\frac{1}{4}$	0 10 $\frac{1}{4}$	0 0 $\frac{3}{4}$	7 5 $\frac{1}{4}$
" 5 ...	0 0 $\frac{1}{4}$	...	0 10 $\frac{1}{4}$	0 2 $\frac{3}{4}$	0 0 $\frac{1}{2}$	0 1	0 0 $\frac{1}{2}$	0 2 $\frac{1}{4}$	0 0 $\frac{1}{2}$	1 6 $\frac{1}{2}$
" 6 ...	0 0 $\frac{1}{2}$	...	0 2 $\frac{1}{2}$	0 0 $\frac{1}{4}$	...	...	0 0 $\frac{1}{2}$	0 0 $\frac{1}{2}$	...	0 4 $\frac{1}{4}$
" 7 ...	0 7 $\frac{3}{4}$	0 3 $\frac{1}{2}$	2 4 $\frac{1}{2}$	0 2 $\frac{3}{4}$	0 0 $\frac{3}{4}$	0 8	0 2 $\frac{1}{4}$	0 7 $\frac{1}{2}$	0 0 $\frac{1}{4}$	4 8 $\frac{1}{4}$
" 8 ...	0 3 $\frac{1}{2}$	0 1 $\frac{1}{2}$	1 0	0 1	0 0 $\frac{1}{4}$	0 1 $\frac{1}{4}$	0 0 $\frac{3}{4}$	0 2 $\frac{1}{2}$	0 0 $\frac{1}{2}$	1 11 $\frac{1}{4}$
" 9 ...	0 9 $\frac{1}{2}$	0 4 $\frac{1}{2}$	1 9	0 4 $\frac{1}{2}$	0 1	0 1 $\frac{3}{4}$	0 3	0 4 $\frac{1}{4}$	0 0 $\frac{1}{2}$	4 2
" 10 ...	1 4	0 2 $\frac{1}{2}$	2 7 $\frac{1}{4}$	0 1 $\frac{1}{4}$	0 0 $\frac{1}{4}$	...	0 0 $\frac{1}{4}$	0 1 $\frac{1}{2}$	0 0 $\frac{1}{4}$	4 5 $\frac{1}{4}$
" 11 ...	0 4 $\frac{1}{2}$	0 0 $\frac{1}{2}$	1 8	0 0 $\frac{1}{4}$	0 0 $\frac{1}{4}$	0 1	...	0 1 $\frac{1}{2}$	...	2 3 $\frac{1}{2}$
" 12 ...	...	...	0 0 $\frac{3}{4}$	0 0 $\frac{3}{4}$	...	0 0 $\frac{3}{4}$	...	...	0 0 $\frac{1}{2}$	0 2 $\frac{3}{4}$
" 13 ...	...	...	0 5 $\frac{1}{2}$	0 0 $\frac{1}{2}$	...	0 0 $\frac{3}{4}$	...	...	0 0 $\frac{1}{2}$	0 7 $\frac{1}{4}$

— Pegs Nos. 12 and 13 were put down and measurements recorded from the 23rd August 1901.

APPENDIX L.

Table of Rainfall in 1898, the year of the great Kalekhan landslip.

Daily rainfall in the month of August 1898.			Record of monthly rainfall in 1898.		
1	...	4.82 inches.	January	...	0.09
2	...	0.55 "	February	...	10.27
3	...	0.16 "	March	...	0.05
4	...	0.23 "	April	...	0.50
5	...	0.18 "	May	...	1.22
6	...	0.45 "	June	...	19.89
7	...	0.39 "	July	...	22.32
8	...	0.26 "	August	...	52.27
9	...	0.02 "	September	...	11.88
10	...	12.16 "	October	...	0.30
11	...	4.81 "	November	...	1.43
12	...	3.67 "	December	...	3.94
13	...	7.87 "			
14	...	2.57 "			
15	...	2.95 "			
16	...	3.85 Total to date 44.94"			
17	...	0.16 Kalekhan landslips			
18	...	0.73 inches			
19	...	0.19 "			
20	...	0.47 "			
21	...	1.30 "			
22	...	—			
23	...	0.21 "			
24	...	0.23 "			
25	...	0.16 "			
26	...	1.52 "			
27	...	0.33 "			
28	...	0.92 "			
29	...	0.59 "			
30	...	0.40 "			
31	...	0.12 "			
Total ... 52.27 inches.					
				Total	124.16 inches.

Copy of Resolution No. 3 of a Meeting of the Municipal Board

of Meini Tal, held on the 8th July 1898.

G. 1547.W. dated 24th June 1898, forwa
ing a copy of Resolution No. 1544.W. dated 1st Jan
in connection with the safety of the Sher-kadanda hi
and the 1548. The report at Naini Tal was read and filed.

True Copy
Wm
RK
201X/45

MUNICIPAL BOARD'S OFFICE, NAINI TAL.

No. _____ dated the _____ 194_____

Copy forwarded to _____

with reference

o his application dated letter

Secretary,

Municipal Board.

Register No. 1903

V (C)

No. 2309 ²⁴⁷ Wor 1898.

GOVT., N.-W. P. AND OUDH,
BUILDINGS AND ROADS BRANCH.

PUBLIC WORKS DEPARTMENT.

Dated Naini Tal, the 8th August, 1898.

C. W. ODLING, Esq., C. S. I.,
SECTY. TO GOVT., N.-W. P. AND OUDH, P. W. D.,

The Chairman,
Municipal Committee,
Naini Tal.

Ordered that a corrected copy of the
be forwarded for information, in continuation of
this office No. 1895W/247 of the 24th June, 1898, with the
request that the corrections on pages 1, 2 and 3
(paragraph 18) may be carried out in the copies already
forwarded.

[Signature]

Registrar,

For Secretary.

[Signature] 8/8/98

Corrected copy of Resolution No. 1544W of

1898, 24th June.

No. 1544W. OF 1898.

GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
BUILDINGS AND ROADS BRANCH.

DATED NAINI TAL, THE 1ST JUNE 1898.

RESOLUTION BY HIS HONOR THE LIEUTENANT-GOVERNOR, NORTH-
WESTERN PROVINCES, AND CHIEF COMMISSIONER OF OUDH.

READ—

- (1) Resolution No. 8W.A., dated the 9th July 1895, by His Honor the Lieutenant-Governor, in the Public Works Department.
- (2) Resolution No. ¹⁹³⁹
XI-44B, dated the 10th July 1895, by His Honor the Lieutenant-Governor, in the Municipal Department.
- (3) Weekly reports by the Executive Engineer, Ayarpata Division, commencing from the 15th of June, 1895 and ending 16th April, 1898.
- (4) Annual reports by the Executive Engineer, Kumaun Division, on the condition of the hill slopes round the Naini Tal Lake for the years 1895-96-97.
- (5) Annual reports by Mr. G. B. Scott, Superintendent, Land Records Surveys, on the theodolite observations from Tonnochy's and Jesmond Villa stations.

Read also—

- (6) Report of the (Beresford) Committee convened under G.O. No. 2609, dated the 22nd April 1895, to consider the safety of Government House, Naini Tal.
- (7) Report on the geological structure and stability of the hill slopes around Naini Tal, by T. H. Holland, Esq., Officiating Superintendent, Geological Survey of India.

OBSERVATIONS.—In 1894 and 1895 the question of the safety of Government House and the stability of the Sher-ka-Danda Hill received the very careful attention of Government. In addition to a prolonged and careful examination of Government House and Sher-ka-Danda Hill by a Special Committee of Engineers under the presidency of Mr. Beresford, the whole question of the stability of the hill slopes around Naini Tal was considered with the assistance of reports received from officers of the Geological Department of India. The general decisions arrived at were—

- (1) to give effect to the recommendations of the Committee contained in a report dated the 22nd April 1895 ;
- (2) to place an energetic and able officer of the Public Works Department on special duty to supervise the several works on Sher-ka-Danda Hill and to advise the Municipality ;

(3) to complete the contour map of Naini Tal in order that a careful examination of the hill slopes might be made by the officers of the Geological Department.

2. The recommendations of the Beresford Committee deal principally with Government House and the crack existing along the top of Sher-ka-Danda Hill.

3. Sections (1), (2), (3), (4), (5), (10), and (11) of paragraph 19 of the Committee's report were all carried out and completed by the beginning of August 1895 at a cost of about Rs. 4,000, and the observations recommended by sections (6), (7), (8), (9), (13), and (14) have now been carefully recorded up to the present time. Before drawing any conclusions from a perusal of these records, it is first necessary to state briefly what works besides those mentioned above have been carried out to completion and have obviously had an effect on the observations.

4. In July 1895, Mr. H. S. Wildeblood, Executive Engineer, was deputed to take charge of the works considered advisable to be undertaken for the safety of the Sher-ka-Danda Hill and to assist Mr. Holland, of the Geological Department, in his investigations of the hill slopes, and to advise the Municipality. For the purpose of the works required a portion of the Sher-ka-Danda Hill, lying, roughly speaking, between the Club ravine on the west and the Ravenswood spur on the east, the portion requiring immediate attention, was placed under the control of the Public Works Department.

5. In August an estimate, amounting to Rs. 87,712, was submitted, providing—

- (1) for the lining with lime masonry of all unlined ravines which it was considered advisable to protect ;
- (2) for building revetment walls on the hillsides and breast walls on roads wherever required ;
- (3) for the remodelling of the bridle roads and providing them with inner road gutters, leading the drainage into the lined ravines, and sloping the road surface inwards in order that none of the drainage may flow over the outer edge and on to the hillside ;
- (4) sloping off and closing injurious foot-paths on the hillsides (except those leading the drainage into the lined ravines, which it was proposed to improve and utilize);
- (5) driving adits into the hillside, as recommended by Mr. Oldham, to tap the subsoil drainage.

This estimate was sanctioned, and the whole of the works carried out and completed by the beginning of June 1896. The area covered by these works is that portion of the Sher-ka-Danda Hill reported on by the 1880 Committee, and extends from Cheena Lodge on the west to Melville Hall on the east.

The works carried out were maintained at the cost of Government until the 1st of November 1896, when they were formally transferred to the Municipality.

6. Orders were also issued by the Municipal Department in the Resolution of 10th July 1895 regarding the treatment of tennis courts, gardens, and platforms. The orders ran thus :—

“Tennis courts and platforms should be now covered with a layer of well rammed clay and should be properly drained. If preferred, a tennis court can be broken up and sloped off, so that the water may pass off rapidly.”

These orders were based on the recommendations of the Committee of 1880, which were—“The platforms round every house should be covered with a six-inch layer of well rammed clay or other material impervious to water. Gardens and cultivated terraces should be absolutely prohibited. Those that exist should be covered with clay and turf immediately, and existing lawn tennis grounds should only be permitted to remain on condition that similar precautions are taken.”

With regard to these orders, Mr. Wildeblood represented to the Government that tennis grounds and well consolidated platforms throw off rainfall very freely indeed and certainly more freely than the natural slope of the hillside, covered as it is with vegetation, which prevents the flow of the water and holds the latter until it soaks into the porous material of the capsoil. He considered that, in order to avoid the expense of treating the tennis courts, gardens, and platforms with clay, the owners would slope them off, and that when sloped off and covered with vegetation they would absorb more water than in their original condition. It was pointed out that gardens absorb rainfall to a considerable extent, but not more than the natural hillside covered with vegetation. These conclusions were arrived at from personal observations during heavy rain. He therefore did not consider a layer of clay necessary, as it would be very expensive, owing to the limited amount available and the distance it would have to be carried. For gardens he recommended that they should be given an inward slope of one in twenty and well rammed and drained by a cheap drain running along the lower side of the slope into the nearest masonry channel, ten per cent. of the area being left unrammed for garden purposes.

7. This representation, differing so widely from the recommendations of all the former Committees, was fully and carefully discussed. Owing to the different conditions of the several portions of the hillside, it was thought it was not applicable generally to the whole hill. It was pointed out that along the ridge, for example, the capsoil is very pervious to water, the platforms consisting of earth full of large blocks of stone with many hollows and cracks, which take a great deal of water, although covered with a coating of *bajri*. Some are on shale rock broken and fissured, right across the stratification, which admit water in the most injurious manner. It was considered that a layer of good clay over such platforms would undoubtedly be most beneficial in assisting rapid surface drainage and protecting the interior of the

hill from the injurious effect of percolating water. On the other hand, it was considered that there were several estates on the lower portions of the hill where the absorption of rainfall is unimportant and in which special precautions are consequently not required.

8. To give effect to these views a map was prepared, which divided the hill into three portions :—

(a) Coloured red, defining the estates on the ridge the terraces and platforms of which it was advisable should be clayed over.

(b) Coloured blue, defining the estates where ordinary terraces may be left, being dealt with as proposed in Mr. Wildeblood's recommendations (*i.e.*, that the platforms and gardens of these estates are not to be covered with clay or brought to the original slope of the hillside, but are to be drained by shallow surface drains leading into the adjacent road or ravine drains).

(c) Coloured yellow, defining estates where special precautions are not required.

9. These proposals dividing the hill into portions requiring different treatment were approved of by Government, and the Municipality was advised accordingly. The coloured portion of this map also defines what is known as the "prohibited area," *i.e.*, the area on which building operations, excavations, or stone quarrying are prohibited without the express sanction of Government. A copy of this map is attached to this Resolution as accompaniment No. I.

10. It was proposed in section (12) of paragraph 19 of the report of the Beresford Committee to cover the St. Loo tennis courts with a six-inch layer of limestone metalling; but for the reasons given above it was considered unnecessary, and in the estimate mentioned in paragraph 5 provision was made for the proper sloping and drainage of the courts.

11. The adits or tunnels for the drainage of the capsoil were commenced in December 1895, and on completion of the works five tunnels had been made: one at Spring Cottage, one to the west of the above, one near the west entrance to St. Loo grounds, one at Springfield gate, and one in the Club ravine. These tunnels have acted satisfactorily, the discharges on two dates during the rains of 1896 being as follows :—

	1st August 1896.	19th September 1896.
	Gallons.	Gallons.
East Spring Cottage tunnel ...	28½	21 $\frac{9}{11}$ per minute.
West Spring Cottage tunnel ...	28½	20 "
St. Loo ...	½	$\frac{16}{37}$ "
Springfield gate ...	1	1 $\frac{1}{7}$ "
Club ravine ...	1½	1½ "

The most important of these tunnels (the east Spring Cottage tunnel) was driven a total length of 38 feet. The material at the end of the tunnel consisted of loose, slaty rock, blue clay, and boulders. None of the adits were driven into the rock underlying the capsoil, as the springs were met before the rock was reached. The behaviour of those constructed will be carefully watched and their discharges recorded during the yearly rains, but at present the data available does not appear sufficient to warrant any great expenditure in the driving of deep adits, though short adits driven at places indicated by large springs would, as pointed out by Mr. Wildeblood in his report, undoubtedly relieve the capsoil of subterranean accumulations of water, and would be useful adjuncts to the general scheme of rapid surface drainage.

12. The question of adits has been very fully discussed by Mr. Holland in his report on the geological structure of the hills round Naini Tal (paragraphs 110 to 115). He mentions the springs for the relief of which the five adits noted above were constructed, and says: "all these springs are situated at points where the deeper water-carrying strata are brought to the surface by an increase in the surface slope, and it naturally follows that an artificial addition to such natural relief must increase the frictional stability of the hill above, besides preventing the soaking of so much water into the portions of hill below."

13. The question of driving an adit directly under Government House was also fully considered both by the Beresford Committee and by Messrs. Oldham and Holland. Mr. Oldham proposed that an adit should be driven into the south face of the hill at a convenient spot not less than 75' or more than 100' below Government House. He pointed out that the only practical means of dealing with the cause of the mischief to Government House was "by drainage works which would tap the inside of the hill, carry off the water, and so keep the body of the rock dry. The fact that it is only in the rains, when the rocks are waterlogged, that any movement takes place, shows that if they could be kept dry, or nearly as dry as they are for three-quarters of the year, nothing need be apprehended." He added that the effect of the tunnel might only be palliative, but that it was almost certain to have a beneficial effect.

14. Mr. Holland says: "there is one area in which adit drainage is likely to have beneficial effect, and that is the area of low dips under Government House. The most suitable spot appears to be where the ravine running down east of Brackenbury Hall meets the 7,200' contour. An adit driven east-north-east at this point for a distance of 150' would approach the line of shearing,..... which is probably a subterranean watercourse, and would relieve much of the water entering the Government House compound..... Such an undertaking would, in my opinion, be the most effectual means of arresting the destructive differential settlement which has been in

progress at least since the construction of the plateau upon which Government House stands."

15. Regarding Mr. Oldham's proposal, Mr. Beresford, in a memorandum dated 19th May 1895, said: "The length of the adit would be about 300', and its section would require to be $5\frac{1}{2}'$ in height by $4\frac{1}{2}'$ in width, to give room for working and for fixing props and roof boards if necessary. The cost would be at least Rs. 5 per footrun, or say Rs. 1,500 or Rs. 2,000 in all to begin with. The value of the adit as a drain would be estimated hereafter by the volume of water which would flow out of its mouth during and after the rains. In my opinion, and in that of several members of the Committee, the drainage effect of such an adit would be trifling, if any. The important point is to prevent water from entering the hill as far as possible, and not to encourage its circulation through the body of the hill. The construction of the proposed adit would, however, increase our knowledge of the interior of the hill, and show whether the fissure in the plateau extends to the depth assumed, and if the local officers consider that an adit 250' to 300' long can be made for Rs. 1,500, the experiment might be worth the cost."

16. Owing to the expense and the purely experimental nature of this adit and the doubts of the Committee as to its advisability, it was decided not to undertake it until the effect of the other remedial measures had been fully tested.

17. It may be mentioned here that Mr. Oldham, in submitting Mr. Holland's report in December 1896, again referred to the question of adits and was doubtful of the advisability of long tunnels. He observed for the prevention of landslips or settlement of the hillside it is only necessary to prevent the accumulation of water in the soilcap, which he considered, judging from the data available, as not likely to extend beyond 50' and never beyond 100' measured at right angles to the surface of the hill.

18. From a perusal of the weekly and monthly record of observations on Government House and Government House Hill, which have been regularly recorded since the 15th June 1895, the following are the most noteworthy facts that have been brought to the notice of Government:—

(a) The principal cracks in Government House have increased as follows:—

	Inches.
(1) North crack in west wall of dining room ...	36
(2) Crack in floor of conservatory ...	48
(3) Crack over south door of east wall of dining room, ...	40
(4) Crack over west window of billiard room ...	28
(5) Crack under north window of east wall of room No. 19, staff quarters.	17

(b) The total subsidences at the points where levels have been recorded are—

	Inches.
(1) North plinth, east verandah	1'308
(2) Centre of east steps, east verandah	1'608
(3) Floor level, north-east corner of dining room	1'092
(4) Floor level, south-east corner of dining room	1'044
(5) Level of <i>chaukat</i> , south door, His Honor's office	1'632
(6) Centre of plinth on portico	1'584
(7) Bathroom door <i>chaukat</i> , north-east corner, staff quarters.	1'788
(8) Sill of <i>chaukat</i> , south door, billiard room	1'008
(9) Plinth, south-west opening, west verandah	1'068

(c) The increase in the width of the cracks along the ridge and the total subsidence of the south pillars below the north are—

			Increase in width of cracks.	Total subsidences.
			Inches.	Inches.
Pillars A and B, Lala Durga Sah's tennis court	...	...	'32	'66
" E and F, St. Cloud compound	...	...	'82	'40
" G and H in Snow View compound	...	...	1'00	1'44
" B and I in Lala Durga Sah's tennis court *	...	...	A decrease of '09 inches.	'06
" D and J in Lala Durga Sah's tennis court	...	...	'65	'84

* In this case it appears that the crack has closed, possibly due to some movement of the northern portion, although the difference in the level of the pillars shows a subsidence of the southern portion. Both pillars appear to have sunk a small amount.

The cracks and principal subsidences noted in (a) and (b) above are shown on the plan of Government House attached to this Resolution as accompaniment No. 2.

The position of the observation pillars along the ridge noted in (c) above are shown on the plan attached to this Resolution as No. 2A.

19. By a reference to the graphic chart of cracks, subsidence, and rainfall attached to this Resolution as accompaniment No. 3 it will be observed that the greatest increase in the cracks and the most marked subsidences always occurred after heavy rain. In 1896, when the rainfall was comparatively light and well distributed, the increases are not so marked as in 1897, when the extremely severe storm of 27th September tested the protective works to the utmost. This storm wrecked the roads and bridges outside the valley to an extent unequalled since the landslip year of 1880, damage amounting to 2½ lakhs of rupees being done, and the immunity of Naini Tal itself is undoubtedly due in a great measure to the effect of the protective works of 1896. It may be observed that during this storm the discharge from the hillsides into the lake was so much greater than the lake could discharge through its sluices that the roads round the lower end

of the lake were flooded. This occurred twice during the rains of 1897, and points conclusively to the satisfactory working of the drainage system.

20. The theodolite observations (recommended in paragraph 19, section 13, of the Beresford Committee's report), of which a chart is attached as accompaniment No. 4 to this Resolution, have not at present been recorded a sufficient length of time to enable any definite conclusion to be drawn from them. In 1896 and 1897 the recorded readings show that no movement had taken place, but in 1898 the following slight differences appear. The line from the observation station at Tonnochy's passing through the tar line on the servant's house below Alma Cottage and pillars 4 (below Braeside) and S (below Ravenswood) were originally in one dead line, with pillar 10 above the Ramsay Hospital. The reading on pillar 10 is precisely the same as before, but the three points mentioned above show differences of 18 seconds, 35 seconds, and 18 seconds respectively. The horizontal movements corresponding with these angles would be about—

				Inches.
Servants' houses, Alma Cottage ...	...	...	...	1
Pillar No. 4 ...	...	...	...	6
„ No. 8 ...	...	...	...	3

The first may be neglected, as the breadth of the tar line would give this difference. On the other hand, pillar 8, as seen from Jesmond Villa, is practically unchanged, being only 6 seconds different to the original reading. The line running along the ridge through pillars 1, 2, and 3 under Snow View and Government House are still exactly in line and show no movement. All the other observations from Tonnochy's show no change greater than 4 seconds, and this may be neglected, as the instrument used only reads to 5 seconds.

21. The observations from Jesmond Villa reveal only two real discrepancies, *viz.*, pillar 6 under Edgehill, and the rod on wall under roof of upper servants' quarters of Ravenswood. The present reading gives a difference of 30 seconds with the original reading, which for the distance would give a horizontal movement of 6" (about); but as both points are still exactly in one line, Mr. Scott, who records the observations, concludes that his original readings must be wrong, as it is not likely that the two points would have changed exactly the same distance, especially as all the other points in the neighbourhood are exactly the same as before. All other angles from Jesmond Villa are the same as before within the limit of 5 seconds.

22. Mr. Scott, in submitting his report, points out that all the various differences in angles are positive quantities, that is, towards the lake. Had they been errors of observation, there is no reason why they should not have been positive and negative or all negative. He mentions this, as, although it may only be a coincidence, it is peculiar and worthy of remark.

23. The contoured survey map of Naini Tal attached to this Resolution as accompaniment No. 5 was commenced in 1894 by

Mr. F. F. Freeman, Extra Assistant Superintendent, Survey of India, and completed in 1895 by Mr. G. B. Scott, Superintendent, Land Records Surveys. The estimated cost of this work amounted to Rs. 3,500. Printed copies of the map were supplied to Mr. Holland in February 1896, who was then enabled to prepare his final Geological Report on the state of the hillsides. In this report, which is necessarily very technical, Mr. Holland has very fully discussed the geological history of the hills, the composition of the rocks, their state of preservation, the direction and inclination of the dip of the strata, the variations in the sub-aërial conditions, the action of water, the classification of landslips, their prevention, as well as a general summary on the results arrived at by the numerous committees, and a description of special sites.

24. His general conclusions as regards Government House and the Sher-ka-Danda Hill are very clearly stated. He says: "the expansion of the surface rocks which follows the heat of the hot season and the warmer water circulating during the rains is naturally manifested in the direction of least resistance. And as the warm season and the rainy season are consecutive and in part coincident, they combine to produce a small, but inevitable, annual movement down the hillside along the bedding planes. As the contraction which attends the following cold and dry seasons cannot bring the rocks back to their original places, the movement which has taken place is manifested by the production of cracks opening out at the end of the rains..... I see no escape from the conclusion that there is a decided, though small, annual creep of the rocks lakewards, and I agree entirely with Mr. Oldham in recognising the longitudinal cracks which open out and increase yearly on Sher-ka-Danda as only a partial visible manifestation of the movement which is recognised everywhere in rocks of this nature to be the precursor of serious landslips."

"Drainage is the only cure for such evident symptoms of an approaching landslip..... As long as water is allowed to enter at the higher levels, the general movement must necessarily proceed along the dip slopes of such a hill of partially dehydrated argillaceous rocks. The stratification planes immediately under Government House are inclined at a lower angle than the slope of the surface..... There is therefore a movable mass of strata under Government House, which is in the form of a 6° wedge, having a length of 400'. It is the gradual creep of this wedge from the causes explained which produces the cracks parallel to the strike of the strata through Government House, and I should expect that the larger fissure known to exist under Government House extends vertically down only to this gliding plane, which cannot be more than 40' or 50' below the foundations of the house. That this wedge will rapidly slide off like an ordinary landslip is *not possible as long as it is kept dry*, and careful drainage might even arrest much or practically the whole of the creeping movement, whose differential effects are endangering the structural stability of the house above."

He also remarks further on: "with regard to the particular portion of the hill upon which it (Government House) stands, there seems to me to be no possibility, so long as the drainage works are kept in order, of anything approaching a landslip."

RESOLUTION.—The remarks already made indicate that a movement, slow it may be, but which apparently shows no sign of ceasing, is taking place in the upper strata of the Sher-ka-Danda Hill. The most prominent result has been a serious increase in the cracks of Old Government House, which leave no doubt as to its unfitness for habitation. It cannot be said that any of the buildings on that part of the hill, to conserve which special measures have been taken, are altogether free from danger, though there is at present no indication that further immediate serious subsidence is to be apprehended. The local officers and Municipality are from time to time furnished with copies of the observations made, and there being no sufficient grounds for taking measures to prohibit the occupation of houses within the area referred to above, the inhabitants must be left to form their own judgment as to the advisability of living in them.

ORDER.—Ordered that a copy of this Resolution be forwarded to the Commissioner of Kumaun, the Chairman of the Municipal Committee, and Superintending Engineer of the 2nd Circle, Provincial Works, for information.

Ordered also that a copy of this Resolution be sent to the Municipal Department of this Government for information.

C. W. ODLING,

Secretary.

No. _____ W. _____

Dated Naini Tal, the _____ June 1898.

Copy, with _____ spare copies, forwarded to _____

ENCLOSURE:

_____ spare copies.

REGISTRAR,

For Secretary.

No. 1359 of 1897.

GOVT., N.-W. P. AND OUDH.

PUBLIC WORKS DEPARTMENT.

Dated Allahabad, the 6th April 1897

To

The Deputy Commissioner

Naini Tal

R BRANCH. Sir,

In continuation of this office
No. 3318 W.A. dated 1st May 1896, I am directed
3700
to forward for information and record in
your office a printed copy of the report on
the condition of the Hill slopes round the
Naini Tal Lake for the year 1896.

I have the honor to be

Sir

Your most obedient servant

How

Registrar

For Secretary

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Enclosure
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THE GOVT. TO GOVT. N. W. P. AND O.
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Report on the Condition of the Hill slopes round the Naini Tal Lake for the year 1896.

Rainfall.—On the 28th and 29th January snow fell in Naini Tal accompanied by a smart thunderstorm.

The depth of snow did not exceed 2 inches. Light rain was received in February and on the 10th and 11th of May there was a smart fall with thunder, but otherwise the season was remarkably dry.

From the 1st June light rains fell almost daily up to the 13th when the rainy season may be said to have commenced in earnest.

The heaviest fall for the year occurred on the 27th June when 11 inches was registered. The rainfall in July and August was very light, and the rain practically ceased on the 21st August. The average total rainfall registered during the year was as follows :—

1. During the year (1st January—31st December)=78.21".
2. During the months of June—October, (1st June—31st October)=69.55".

On the night of the 30th December there was a heavy fall of snow in Naini Tal averaging 6 inches in depth and on the Kaladungi side of the hill snow fell as low down as Mangali.

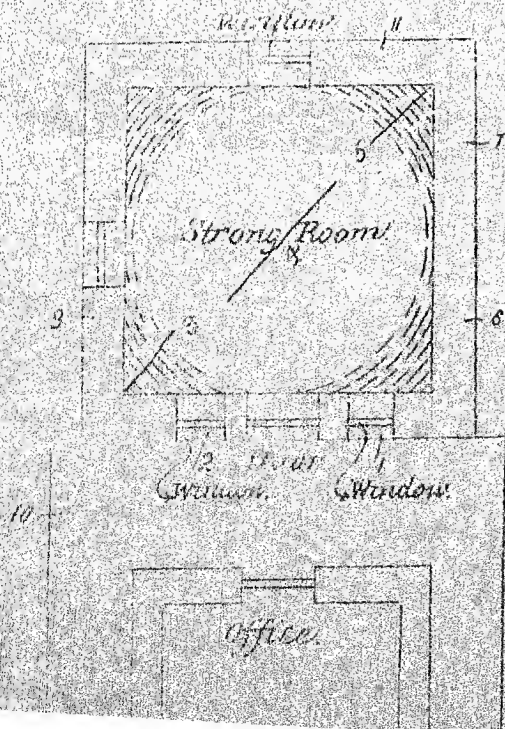
Landslips.—On the 27th June the new Cart Road between the Brewery and Naini Tal was broken by a slip from above in the 20th mile from Kathgodam, but the road was opened to wheeled traffic within a few days.

On the 29th July very heavy local rain fell on the lower hills causing a breach on the Tonga road in the 8th mile from Kathgodam and the collapse of a 25 feet masonry arched bridge. A temporary bridge was thrown over the breach and the road was opened to wheeled traffic on the morning of the 3rd August.

Besides the above no slip of any importance occurred.

Ballia ravine.—A piece of revetment wall on the right bank of the ravine near the forest wood depôt was undermined and fell in on the 27th July, but it was rebuilt at once.

Cracks in building.—The cracks noticed last year in the treasury strong room have not increased in width to any appreciable amount, but the diagonal crack which was only visible last year in the floor (No. 4 on plan) and in the south-west corner (No. 5 on plan) is now visible, also at 2, 3 and 9 in the north-east corner. The cracks are in no way serious. Tell-tales have been placed in eleven places and periodical measurements are made of them. The following sketch and table show the position of the tell-tales and the measurements recorded :—



Date.	Mean rainfall in Naini Tal.	Lake gauge reading at 8 A.M.	Rise in lake.	Fall in lake.	Extent of sluice openings.	Discharge of one sluice in cubic feet.	Remarks.
1st	0.43	0.43	...	...	...	...
2nd	0.77	0.23	...	...	...	...
3rd	0.29	...	...	...	...	...
4th	0.40	...	...	...	...	...
5th	1.72	...	...	...	...	...
6th	1.54	0.13	...	...	...	...
7th	0.51	0.18	0.05	...	...	...
8th	0.18	0.18	...	...	...	...
9th	0.05	0.18	...	...	...	...
10th	...	0.15	...	0.03	...	...
11th	...	0.12	...	0.03	...	...
12th	...	0.10	...	0.02	...	...
13th	0.80	0.08	...	0.02	...	...
14th	1.10	0.26	0.18	...	...	...
15th	1.09	0.45	0.19	...	...	...
16th	1.79	0.40	0.04	...	...	...
17th	1.54	0.86	0.37	...	...	...
18th	0.28	0.90	0.04	...	...	...
19th	0.01	0.86	...	0.04	...	...
20th	1.33	0.83	...	0.03	...	...
21st	0.88	1.05	0.25	...	...	...
22nd	0.21	1.06	...	0.02	...	...
23rd	0.31	1.03	...	0.03	...	...
24th	0.40	1.08	0.05	...	...	...
25th	0.95	1.08	...	...	...	...
26th	5.73	1.18	0.10	...	Opened 3" at 6 P.M.	...	
27th	6.93	3.11	1.93	...	Opened 15" at 6 A.M., and closed to 12" at 7 P.M. Closed to 9" at 10 A.M.	1,238,519 907,335	
28th	.94	2.03	...	1.09	Closed at 11 A.M., opened 6" at 9 P.M.	1,018,225	
29th	.65	1.78	...	0.25	Closed at 8 A.M., and opened 3" at 9 P.M.	276,320	
30th	.39	1.50	...	0.28	Total	3,460,399	
					Add 4 other sluices	13,841,596	
					Total discharge since June 1st, (Carried over)	17,301,995	
Total rainfall since June 1st, (Carried over).	31.39	...	...	...

Record of Rainfall, Lake levels, &c.

July 1896.

Date.	Mean rainfall in Naini Tal.	Lake gauge reading at 8 A.M.	Rise in lake.	Fall in lake.	Extent of sluice openings.	Discharge of one sluice in cubic feet.	Remarks.
Brought forward ...	31.39	...	...	...	Brought forward ...	17,301,995	
1st ...	0.36	1.50	...	...	Closed at 10 A.M., and opened 3" at 9 P.M.	165,594	
2nd ...	0.32	1.46	...	0.01	Closed at 11 A.M.	172,942	
3rd ...	0.24	1.53	0.07	...	...	...
4th ...	0.08	1.69	0.16	...	...	...
5th ...	0.20	1.70	0.01	...	...	...
6th ...	0.19	1.78	0.08	...	...	...
7th ...	0.14	1.83	0.05	...	...	...
8th ...	0.18	1.87	0.04	...	...	...
9th ...	0.12	1.91	0.04	...	...	...
10th ...	0.05	1.94	0.03	...	...	...
11th ...	0.01	1.95	0.01	...	...	...
12th ...	0.05	1.95	...	...	Opened 6" at 8 P.M.	...	
13th ...	1.09	1.56	...	0.30	Closed at 8 A.M., opened 6" at 8 P.M.	286,344	
14th ...	2.11	1.51	...	0.05	Closed at 8 A.M., opened 6" at 6 P.M.	279,480	
15th ...	3.16	1.53	0.02	...	Closed at 10 A.M., opened 3" at 8 P.M.	381,600	
16th ...	1.92	1.94	0.41	...	Opened 6" at 10 A.M.	192,094	
17th ...	0.42	1.46	...	0.48	Closed at 8 A.M.	565,356	
18th ...	0.11	1.86	0.20	...	...	...
19th ...	0.13	1.82	0.16	...	...	...
20th ...	0.24	1.81	...	0.01	Opened 3" at 8 P.M.	...	
21st ...	1.01	1.77	...	0.04	Closed at 10 A.M., opened 6" at 8 P.M.	193,550	
22nd ...	1.02	1.73	...	0.04	Closed at 10 A.M.	377,294	
23rd ...	0.01	1.80	0.07	...	...	...
24th ...	...	1.92	0.12	...	...	...
25th ...	0.14	2.02	0.10	...	Opened 6" at 9 P.M.	...	
26th ...	0.92	1.84	...	0.18	Closed at 8 A.M.	305,954	
27th ...	...	1.99	0.15	...	Opened 3" at 9 P.M.	...	
28th ...	...	1.88	...	0.11	Closed at 8 A.M., opened 3" at 8 P.M.	158,257	
29th ...	1.04	1.78	...	0.10	Ditto ditto	167,804	
30th ...	0.55	1.84	0.06	...	...	...
31st ...	0.01	1.59	...	0.25	Closed at 8 A.M.	481,212	
					Total	3,727,281	
					Add for four other sluices	14,909,124	
Total for the month.	15.82	...	...	...	Total for the month	18,636,405	
Total rainfall since June (Carried over)	47.21	...	...	...	Total discharge since June	35,788,400	

Record of Rainfall, Lake levels, &c.

August 1896.

Date.	Mean Rainfall in Naini Tal.	Lake gauge reading at 8 A.M.	Rise in lake.	Fall in lake.	Extent of sluice openings.	Discharge of one sluice in cubic feet.	Remarks.
Brought forward ...	47.21	...	...	...	Brought forward ...	35,938,400	
1st ...	0.61	1.67	0.08	...	...	...
2nd ...	0.49	1.87	0.20	...	...	...
3rd ...	...	1.93	0.06	...	...	...
4th ...	0.12	1.98	0.05	...	...	...
5th ...	0.81	2.05	0.07	...	...	...
6th ...	2.41	2.30	0.25	...	Opened 9" at 9 A.M., closed to 6" at 8 P.M.	502,744	
7th ...	0.35	1.94	...	0.30	Closed at 10 A.M. ...	402,850	
8th ...	0.59	2.06	0.12	...	Opened 3" at 8 P.M.	...	
9th ...	1.43	2.05	...	0.01	Closed at 10 A.M., opened 6" at 8 P.M.	200,048	
10th ...	3.79	2.33	0.28	...	...	...
11th ...	0.56	1.96	...	0.37	Closed at 8 A.M., opened 3" at 8 P.M.	1,090,612	
12th ...	0.24	2.08	0.12	...	Closed at 8 A.M., opened 3" at 7 P.M.	180,030	
13th ...	0.38	2.20	0.12	...	Closed at 10 A.M., opened 6" at 7 P.M.	231,613	
14th ...	0.04	1.97	...	0.03	Closed at 8 A.M., opened 3" at 7 P.M.	378,664	
15th ...	0.14	1.98	0.01	...	Closed at 8 A.M., opened 6" at 7 P.M.	190,606	
16th ...	0.53	1.80	...	6.18	Closed at 7 A.M., opened 6" at 7 P.M.	332,292	
17th ...	0.38	1.69	...	0.11	Closed at 8 A.M. ...	344,773	
18th ...	1.01	1.91	0.22	...	Opened 3" at 8 P.M.	...	
19th ...	1.09	2.06	0.15	...	Closed at 8 A.M., opened 3" at 8 P.M.	170,640	
20th ...	0.70	2.07	0.01	...	Closed at 8 A.M., opened 6" at 6 P.M.	180,389	
21st ...	4.54	2.26	0.19	...	Opened 9" at 8 P.M.	803,804	
22nd ...	1.09	2.02	...	0.24	Closed at 8 A.M., opened 3" at 6 P.M.	522,858	
23rd ...	0.04	2.20	0.18	...	Closed at 6 A.M., opened 3" at 8 P.M.	185,292	
24th ...	...	2.20	...	...	Closed at 10 A.M., opened 6" at 8 P.M.	429,168	
25th ...	0.27	2.07	...	0.13	Closed at 8 A.M., opened 3" at 6 P.M.	356,052	
26th ...	...	2.19	0.12	...	Closed at 8 A.M., opened 3" at 8 P.M.	169,444	
27th ...	0.03	2.26	0.07	...	Closed at 10 A.M., opened 6" at 8 P.M.	219,254	
28th ...	0.06	2.06	...	0.20	Closed at 8 A.M., opened 3" at 8 P.M.	358,824	
29th ...	...	2.10	0.04	...	Closed at 8 A.M., opened 6" at 9 P.M.	181,464	
30th ...	...	1.98	...	0.12	Closed at 6 A.M. ...	260,780	
31st ...	...	2.17	0.19	...	Opened 6" at 8 P.M.	...	
Total for the month.	21.73				Total ...	7,697,828	
					Add for 4 other sluices ...	30,789,312	
Total rainfall since June, (Carried over).	68.94				Total for the month ...	38,486,640	
					Total discharge since June (Carried over) ...	74,425,040	

Record of Rainfall, Lake levels, &c.

September 1896.

Date.	Mean rainfall in Naini Tal.	Lake gauge reading at 8 A.M.	Rise in lake.	Fall in lake.	Extent of sluice openings.	Discharge of one sluice in cubic feet.	Remarks.
Brought forward ...	68.94	...	...	...	Brought forward ...	74,425,040	
1st ...	...	1.07	...	0.20	Closed at 8 A.M. ...	349,063	
2nd ...	...	2.10	0.19	...	...	...
3rd ...	...	2.21	0.05	...	Opened 3" at 7 P.M. ...	...
4th ...	...	2.22	0.01	...	Closed at 8 A.M., opened 3" at 8 P.M. ...	203,593	
5th ...	...	2.13	...	0.09	Closed at 8 A.M. ...	184,392	
6th ...	...	2.25	0.12	...	...	...
7th ...	...	2.37	0.12	...	Opened 3" at 6 P.M. ...	...
8th ...	...	2.33	...	0.04	Closed at 8 A.M. ...	223,804	
9th ...	...	2.37	0.04	...	...	...
10th ...	...	2.43	0.06	...	...	...
11th ...	...	2.47	0.04	...	Opened 3" at 7 P.M. ...	...
12th ...	...	2.43	...	0.04	Closed at 8 A.M. ...	211,296	
13th ...	...	2.46	0.03	...	...	...
14th ...	...	2.49	0.03	...	Opened 3" at 7 P.M. ...	...
15th ...	0.12	2.36	...	0.13	Closed at 8 A.M. ...	210,587	
16th ...	0.21	2.44	0.08	...	...	...
17th ...	0.04	2.52	0.08	...	Opened 3" at 7 P.M. ...	...
18th ...	...	2.37	...	0.15	Closed at 8 A.M. ...	211,471	
19th ...	...	2.42	0.05	...	...	...
20th ...	0.05	2.45	0.03	...	...	...
21st ...	...	2.50	0.05	...	...	...
22nd ...	...	2.55	0.05	...	...	...
23rd ...	0.03	2.59	0.04	...	...	...
24th ...	...	2.62	0.03	...	...	...
25th ...	...	2.63	0.03	...	...	...
26th ...	...	2.67	0.02	...	...	...
27th ...	...	2.68	1.01	...	...	...
28th ...	...	2.68	...	...	...	...
29th ...	...	2.67	...	0.01	...	...
30th ...	...	2.68	0.01	...	...	...
Total for the month ...	0.45				Total ...	1,694,841	
					Add for four other sluices ...	6,379,364	
Total rainfall since 1st June ...	69.39				Total for the month ...	7,974,205	
					Total discharge since 1st June ...	82,399,240	

H. S. WILDERLOOD,

The 21st January 1897.

Executive Engineer, Kumaun Division.

Record of Rainfall, Lake levels, &c.

September 1896.

Date.	Mean rainfall in Naini Tal.	Lake gauge reading at 8 A.M.	Rise in lake.	Fall in lake.	Extent of sluice openings.	Discharge of one sluice in cubic feet.	Remarks.
Brought forward ...	68.34	Brought forward ...	74,425,040	
1st	1.07	...	0.20	Closed at 8 A.M. ...	349,068	
2nd	2.10	0.19	
3rd	2.21	0.06	...	Opened 3" at 7 P.M.	
4th	2.22	0.01	...	Closed at 8 A.M., opened 3" at 8 P.M. ...	203,593	
5th	2.13	...	0.09	Closed at 8 A.M. ...	184,392	
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22nd	2.55	0.05	
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24th	2.62	0.03	
25th	2.63	0.03	
26th	2.67	0.02	
27th	2.68	1.01	
28th	2.68	
29th	2.67	...	0.01	
30th	2.68	0.01	
					Total ...	1,594,841	
					Add for four other sluices ...	6,379,364	
Total for the month ...	0.45				Total for the month ...	7,974,205	
Total rainfall since 1st June ...	68.34				Total discharge since 1st June ...	82,899,240	

The 21st January 1897.

H. S. WILDERBLOOD,
Executive Engineer, Kumaon Division.

an 16/11/99
1200

Register No. 3280

XII

RAJAH COMMISSIONER'S OFFICE.
No. XVIII.76 dated N. Tal the 1st Nov 1897

Collection of papers regarding Government
House and Shekandanda Hill
Rajni Tal 1895

Forwarded to the President Municipal
Committee Rajni Tal for information
and record, with reference to his
No: 1947/XII, dated 21st Ultimo.

S. G. Guleria

Head Assistant,
for R. E. Hamblin Esq.,
Commissioner

Enclosure
3 copies

meb

PART I.

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Nos. C.532—37B.R. OF 1880.

GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
BUILDINGS AND ROADS BRANCH.

DATED NAINI TAL, THE 22ND SEPTEMBER 1880.

RESOLUTION BY HIS HONOR THE LIEUTENANT-GOVERNOR, NORTH-WESTERN PROVINCES, AND CHIEF COMMISSIONER, OUDH.

GRAVE anxiety and alarm having been most naturally created by the late appalling catastrophe and by the condition of the southern face of the Sher-ka-danda hill at Naini Tal after the extraordinary rainfall of the 17th to the 19th of the current month, His Honor the Lieutenant-Governor of the North-Western Provinces and Chief Commissioner of Oudh feels that it is absolutely necessary to appoint at once a Committee for the careful examination of the hillside and consideration of remedial measures, in order both to ascertain, as exactly as may be possible, the real condition of the hill at present, and to lay down the protective measures which it may be desirable to adopt for ensuring the security of life and property in the future.

The Committee will consist of—

Lieutenant-General the Hon'ble Sir H. Ramsay, C.B., K.C.S.I.	... PRESIDENT,
Colonel H. A. Brownlow, R.E., Secretary to Government, Public Works Department,	} MEMBERS,
Captain G. F. O. Boughey, R.E., Personal Assistant to Chief Engineer, Buildings and Roads Branch,	
Mr. J. S. Beresford, Personal Assistant to Chief Engineer, Irrigation Branch,	
Mr. F. H. Ashhurst, Executive Engineer, Kumaun Division, Public Works Department,	
Lieutenant H. A. Yorke, R.E.	... Secretary to the Committee;

and will assemble, without loss of time, under the orders of the President, hearing the evidence and opinions of any gentleman of experience whom it may be desirable to consult, and taking such other steps as shall appear necessary, for the purpose of laying before Government a full and clear report on the present condition of the hillside and on the remedial measures to be adopted.

ORDER.—Ordered that a copy of this Resolution be forwarded to the officers mentioned above for information and guidance.

H. A. BROWNLOW, COLONEL, R.E.,
Secy. to Govt., N.-W. P. and Oudh.
P. W. Dept., B. and R. Branch.

No. C.611B.R., dated Naini Tal, the 11th October 1880.

From—COLONEL H. A. BROWNLOW, R.E., Secy. to Govt., N.-W. P. and Oudh,
P. W. Dept.,

To—Secretary to Government, N.-W. P. and Oudh, General Department.

I HAVE the honor to forward, for the information of Government, a copy of the report prepared by the Committee appointed to enquire into the condition of the Sher-ka-danda hill.

2. If His Honor the Lieutenant-Governor thinks it desirable, the report shall be printed.

3. A map is forwarded with this report for reference. I am to request that the map may be returned to the Public Works Secretariat when quite done with.

Report of the Committee appointed by Resolution Nos. C.532—37 B.R., dated Naini Tal, the 22nd September 1880, to enquire into the condition of the Sher-ka-danda hill.

1. THE Members of the Committee wish to place on record their deep sense of the grave responsibility which has been laid upon them.
General remarks. On the one hand, a wholesale condemnation of the hillside would involve the loss of many lakhs of rupees to the house and landholders of the station; while, on the other, the safety of hundreds of lives may depend upon the decision arrived at by Government upon the recommendations of the Committee.

2. The opinions expressed in the report are based upon a careful examination of the hillside by all the Members, and are supported by the local experience of several residents of the station, who have come forward with great readiness to assist the Committee in its inquiries.

3. The best thanks of the Committee are due to—

FLEETWOOD WILLIAMS, Esq., C.S.I.,
C. ROBERTSON, Esq., Secretary to Government,
MAJOR-GENERAL RENNY, V.C., R.A.,
W. WALKER, Esq., M.D., M.A.,
COLONEL ANDERSON, Superintendent, Revenue Survey,
MAJOR GARSTIN, Assistant Commissioner,
R. D. OLDHAM, Esq.,
A. LAWDER, Esq., M.I.C.E.,
Mr. F. E. G. MATHEWS, Agent,

for the assistance thus given.

The information supplied by these gentlemen has been of great value, embracing as it does the history of the station for the last 20 years.

4. The geological structure of the Sher-ka-danda hill is somewhat obscure.

Geological structure of the hill. Geologists do not seem to be unanimous about it, and the literature on the subject is scanty. Mr. W. Theobald, Deputy Superintendent, Geological Survey of India, thus describes it:—

“The fact is, that the valley wherein Naini Tal nestles is surrounded by rocks varying greatly in structure, such as splintery schists and massive limestones, which agree in one character only, that of being very disturbed as regards their

stratigraphical arrangement, and much crushed and mechanically disintegrated as regards their petrological condition.”—(*Records, Geological Survey, Vol. XIII, Part 3, page 163.*)

To the ordinary observer the hill seems to consist of a core of rocky shale, the dip of the strata being to the south-west at an angle varying from 30° to 50° . This core is covered by varying thicknesses of disintegrated shale and mud, in which are scattered boulders of limestone, and occasionally of trap, the whole of this crust being in its natural state bound together by a luxuriant growth of grasses, shrubs, and trees. Mr. Lawder, in a letter to the Committee, says:—“Almost the whole of the southern face consists of argillaceous schist and shale, which becomes more or less calcareous towards the eastern end of the Lake and also towards Cheena. The centre portion, or region of probable landslips, is much disintegrated mechanically and chemically * * * * * The argillaceous clay at some distance below the surface is so hard and compact as to require blasting in quarrying it, but it quickly disintegrates under the influence of air and water.”

On the north-east face of the Alma hill there is the outcrop of a band of what appears to be trap, varying in thickness from 10 to 20 feet. This band follows the stratification of the shale in which it is imbedded, and apparently at one time extended over what is now the southern face of Sher-ka-danda hill. Traces of the rock are to be seen *in situ* on the road immediately north of Rosamond's Well and at St. Cloud, while disintegrated pieces of it are found on the roads and hillside as far east as Ravenswood ravine.

5. The examination of the hillside by the Committee leads them to consider that, for the present, no danger of further settlement exists west of Cheena Lodge or east of Melville Hall; but within these limits the hillside is covered with a thick crust of disintegrated shale, which, when saturated with water, is devoid of all cohesion and very liable to slip where the slope is greater than 35° . East of Mr. Saché's premises the character of the hillside changes considerably. Broken shale disappears and its place is taken by stiff clay, in which are embedded large boulders of limestone. Here the hillside is quite sound and no danger of slips is to be apprehended.

6. The Committee is unanimously of opinion that the southern slope of Sher-ka-danda hill, between the limits abovenamed, has been very seriously shaken and injured by the violent rainfall of September 16th to 19th, assisted as it was by the reckless manner in which the hillside has been cut up and disturbed in order to form sites for houses, gardens, roads, and tennis courts.

7. The evidence collected by the Committee proves conclusively that heavy rain now operates to the injury of the hillside in three different ways:—

1st.—The drainage of the hill has by artificial means been concentrated in certain ravines, which in their natural state are not fitted to receive it. Formerly a great proportion of the surface drainage could escape freely in thin sheets by direct downward flow over the whole face of the hill, which was for the most part protected by a thick growth of grass, shrubs, and trees. Now, however, the hillside is cut up in all directions by roads, sites for houses, gardens, and tennis courts. The drainage which collects on these surfaces, and which in heavy rain amounts to a formidable volume of water, is conducted to the nearest ravine and left to find its way down to the Lake as best it can. The beds of these ravines are not only scoured out and deepened, but the rush of water undercuts the banks on either side. The steep slopes of earth and shale supported by these banks thus lose their footing and slip forward, causing a

general settlement of their upper surface. The undercutting then begins again, and the process is repeated as long as rain continues to fall.

2ndly.—Another cause of the settlement of the hillside is to be found in the increase of the volume of the subterraneous springs. Formerly, as above noted, the whole face of the hill was protected by a thick growth of vegetation. This in many places, especially where the slope is great, kept the rain water out of the heart of the hill, throwing it off along the surface like a coating of thatch. Of late years the levelling of sites for houses and roads has much increased, and each clearance so made, unless most carefully drained, admits the water freely into the interior of the hill, from whence it can only escape by flowing along underground channels or percolating through the loose earth and shale. (General Renny, who lives at Tara Hall, states that a large body of water flowed in his compound from the hill above, but that none flowed out, the whole of it being absorbed into the platform surrounding his house.) During heavy rain these underground channels become exposed to very severe action from the water flowing through them under great heads of pressure. If they pass through rock with inclined stratification, the water tends to make the upper strata slip along the lower; if through earth and shale, the water scours out the channel, undermines the whole superincumbent mass, and sooner or later causes a landslip.

3rdly.—In some cases the water, which has penetrated into the hill, may be unable to escape. It is then retained in and saturates the whole hillside. This is a most dangerous state of affairs, as the least undercutting or slipping in a neighbouring ravine may then bring down in a moment an avalanche of mud and shingle, such as that which has lately caused such widespread sorrow and distress. Slips of this nature are the most far-reaching of any owing to their fluidity. Mr. Theobald, Deputy Superintendent, Geological Survey, describes them (Records, Geological Survey, Vol. XIII, part 3, page 164) as "slips * * * * in which water is more or less the prime mover; the result being the descent of a heterogeneous mass of mud and stones, whose power of progression is regulated partly by the slope over which it moves and partly by the amount of fluidity of the materials composing them." Proofs of the correctness of these views could, if necessary, be easily adduced.

8. By one or other of the causes given above, a series of slips and cracks have been produced during the late rains, which have not necessarily any connection with each other (each group being traceable to the action of water in the neighbourhood), but still so extensive and far-reaching as to lead to the impression of a general and connected movement of the whole hillside.

9. The Committee is of opinion that no such general subsidence has occurred, and this point is of great importance. For, if such a movement of the hillside has really taken place, it may happen again during any of the heavy falls of rain which visit this place; and it also points to the possibility of a landslip occurring of such vast dimensions that the Lake would be filled up and Naini Tal would become a thing of the past. Nor can the Committee suggest any means by which such a general and simultaneous settlement of the hillside could be counteracted.

10. It has been suggested by some that the catastrophe of 18th September and the general cracking and subsidence of the hillside were due to an earthquake. But the evidence in support of this view is of the slightest and most contradictory nature, and the Committee deprecate the attempt to attribute to a very remote and dubious cause what is so clearly accounted for by the unusually heavy rainfall, of which there is no doubt. The remarks in paragraph 9 apply also to an earthquake. If such really occurred,

Naini Tal had better be abandoned, for it may occur again at any time, and no money that could be spent would be sufficient to counteract the danger it would cause.

11. There is, however, no insuperable difficulty in dealing with a series of disconnected slips, such as have really taken place : and until some remedial measures are adopted, there is no doubt whatever that further slips will be of frequent occurrence. This probability has been much increased by the damage which the hillside has suffered during the late heavy rain.

12. The following measures are, in the opinion of the Committee, absolutely necessary to prevent further damage and to protect the station from danger in the future :—

(1) All important ravines (see paragraph 19) should be retted at intervals by strong cross-walls curved in plan, with well-guarded flanks (or wing walls) built into the rock on either side. These walls should have considerable batter on the face, the courses being laid at rightangles to the batter.

(2) All ravines should be lined where necessary with side walls and strongly payed flooring laid in lime mortar, the channels being made large enough to carry at least double the maximum flood volume which has been known to flow down them up to date.

(3) The cracks and fissures in the hillside should be carefully searched for, dug out as far as they can be traced, and refilled with well-rammed clay.

(4) The platforms round every house within the limits specified in paragraph 5 (or wherever the civil officer in charge of the station thinks necessary) should be covered with a six-inch layer of well-rammed clay, or other material impervious to water (when houses have been destroyed and abandoned, this might be done at the expense of the public, and not at that of the proprietor).

(5) Gardens and cultivated terraces should be absolutely prohibited. Those that exist should be covered with clay and turf immediately, and existing lawn tennis grounds should only be permitted to remain on condition that similar precautions are taken to prevent the percolation of water into the hillside.

(6) The further erection of houses or other buildings, quarrying of stone, and the excavation of terraces or platforms for any purposes whatever, should be absolutely prohibited in the southern slope of the Sher-ka-danda hill within the limits specified in paragraph 5.

(7) Special care should be taken to prevent injury from house drainage. Every house should have a gutter under the eaves and a catch-water drain round its base. The water from these should be carried in a masonry channel to the most suitable ravine, in which provision should be made for its reception.

(8) House proprietors should be compelled to restore in an efficient manner all retaining walls which are bulged or cracked ; and further, to build such walls where they do not exist, and where their absence has caused, or may hereafter cause, slips in the hill above. Also, where there is any tendency to slip, to slope off the hill immediately above all retaining walls to an angle of 40°. This order should be binding on all proprietors, whether the houses on their estates are occupied by tenants or not.

(9) The civil officer in charge of the station should be responsible for the maintenance in proper order of all watercourses in ravines and of all roadside drains. Special gangs should be employed during the rains to keep the drains free from obstruction and to repair damage immediately it occurs.

7

(10) An honest, efficient, and trustworthy subordinate should be appointed as Inspector of buildings and drains, who should be under the sole orders of, and responsible only to, the civil officer in charge of the station.

(11) All the arrangements for drainage of houses, roads, and property, and the building of all revetment walls, and in short all operations which affect the safety of the station, should be carried out by order of the civil officer in charge, through the agency of this Inspector. Where these necessary improvements are executed on private property, the house or landowner should be made to pay the cost. Private individuals should not be allowed to construct any drains, walls, or buildings without the written permission of the civil officer and the supervision of the Inspector.

(12) All steep slopes should be turfed and planted. Grass-cutting and grazing on the southern slopes of Sher-ka-danda and Cheena should be strictly prohibited.

(13) The civil officer should have power to carry out the above and other measures for the safety of the station without reference to the Municipal Committee.

(14) And, finally, whatever sums are set aside by Government or the Municipality for the maintenance and improvement of drains and roads should be at the disposal of the civil officer, to be expended by him, without reference to the Municipality, in a regular and systematic plan, with the advice, when necessary, of the Superintending Engineer of the Provincial Circle.

13. The above measures will, it is believed, be sufficient to save the station from further damage, but to ensure success they must be carried out promptly, carefully, and completely: and the Committee would lay special stress on the necessity for commencing work at once, so that the more urgently needed portion may be completed by next rains.

14. The cost of these works will be heavy, but they must either be carried out, or the value of property in the settlement will be seriously depreciated. At present it is difficult to estimate the cost with accuracy, but it will be at least two lakhs of rupees. The Municipality are quite unable to find this amount, and it will be necessary for them to apply to Government for assistance.

15. The capital sunk in the station in buildings alone, exclusive of bazárs, is upwards of 25 lakhs, of which four lakhs are in Government property. The whole of this large sum will be depreciated, and much of it entirely lost, unless Government steps be taken to aid in saving the station from destruction.

16. The Committee do not feel called upon to discuss the form which the assistance from Government should take, but would suggest that the amount be lent by Government to the Municipality at four and a half per cent.

17. The above represent the general views of the Committee. It remains now to refer specially to certain localities and houses.

18. The Committee, as stated in the beginning of this report, have visited all houses and ravines in which any sign of settlement has occurred. To describe the condition of every locality thus visited would increase the size of this report to unwieldy proportions. However, there are certain places on the condition of which the Committee desire to give an opinion.

19. There are six main lines of ravines, which, together with the subsidiary watercourses leading into them, require immediate attention. These are—

- I.—The Bara Nadi, including the Club and Fairlight Hall ravines, with all the lesser ones which run into these.
- II.—The upper portion of the Rosamond's Well ravine. (The lower portion is lined and revetted and has stood well. The upper portion now requires similar precautions to prevent the old landslip from coming again.)
- III.—The ravines between old Staff Quarters and Edgehill, which unite in rear of the Mission premises.
- IV.—The ravines east of Edgehill, St. Lee, and Daugh Cot, which unite and cross the Mall close to the Mayo Hotel.
- V.—The Lake View ravine, which crosses the Mall close to the Government Secretariat.
- VI.—The Melville Hall ravine, which passes east of and close to Mr. Saché's premises.

20. The whole of these ravines have been most seriously widened, secured out, and undercut by the late rainfall; and unless the recommendations (1) and (2) of paragraph 12 (remedial measures) are carried out and completed before next rains, further damage to the station will undoubtedly occur. Proper sections, plans, and estimates should at once be prepared, and the work carried out without any delay under the orders of the Assistant Commissioner. Until this is done, the houses in the immediate neighbourhood of these ravines can never be considered safe. To initiate and carry out these extensive and difficult works, the Committee recommend that Government be applied to for the services of an experienced Engineer, who should be placed under the immediate orders of the Commissioner of Kumaun.

21. There are several houses which, while structurally sound, are, in the opinion of the Committee, unsafe during rain and snow, owing to the condition of neighbouring hills and ravines; and in the interests of the public welfare, the Committee feel bound to specify them.

22. Beginning at the western end of the area of disturbance, there are—

Cheena Lodge,
Fairlight Glen,
The Pavilion,

Bridge House,
Windermere,
Anaandale,

which, until the water in the ravines between Rookwood and Cheena is got under thorough control, and until the landslip on the peak of Cheena, near Tonnochy's, has been checked, must be considered as absolutely unsafe during heavy rain. After a year or two, when the works recommended have been carried out, the case may be different.

23. Next in order are Springfield House (which is in a most dangerous condition and should be dismantled) and the Club. The latter is safe at present, but may suffer considerably if the Bara Nadi and Glenmore ravines are not taken in hand and controlled.

24. Passing to the east, the Mission premises are reached. The hill above these is cracked in all directions, and its appearance proves beyond doubt that it was in a very dangerous condition during the late heavy rainfall. The Committee consider that no reasonable expenditure of money would render this hill, between Staff Quarters of old Government House and the Mission premises, perfectly safe from the risk of most dangerous slips during heavy rain, and is therefore compelled to express its opinion that the Mission premises should not be re-occupied. Very possibly, no serious slip may occur for many years to come, but that a dangerous slip will, sooner or later, occur at this point, there can be no reasonable doubt.

25. The next building is that marked on the map as "Omnibus," recently occupied as a milliner's shop by Mrs. Fleming. This is situated at the base of the Edgehill spur, and thereby to a certain extent protected. But to render it quite safe it would be necessary to spend more money than the building is worth.

26. Then come the Mayo Hotel and Morrison's shop. The Committee is unanimously of opinion that neither of these buildings is safe during heavy rain or snow, and that no reasonable expenditure of money can remove the danger to which they are exposed.

27. The next houses are the Uncovenanted Service Bank and the Government Secretariat (shown on the map as Newbury Lodge and Fir Tree Lodge). These are not at present safe during heavy rain, but can be made so by the construction of efficient foot-walls at the base of the hill behind them and by attention to drainage.

Dudley Grove, immediately above Newbury Lodge, should be dismantled.

28. Further east are Mr. Saché's premises. These are safe at present and will remain so if the drainage of the neighbouring ravines is attended to.

Beyond this the character of the hillside changes, and no danger is to be apprehended.

29. Besides the above, there are several houses which have suffered very much during the late rain, being either cracked or distorted or endangered by the slipping and settlement of the bank behind them; and having regard to the public safety and convenience, the Committee recommend that none of the houses mentioned below be let for next season without reference to the civil officer in charge of the station, *viz.*,—

Assembly Cottage.	Blair House.
Dunedin House.	Alma Lodge.
Kumaun Lodge.	Alma House.
Norfolk House.	Glenmore.
Lake View.	St. Helens.
Staff Quarters, old Government House.	Rookwood.
Edgehill.	Blyth Cottage.
Tara Hall.	Oak Cottage.
Brac Side.	Fairlight Glen.

H. RAMSAY.
H. A. BROWNLOW.
G. F. O. BOUGHEY.
J. S. BERESTFORD.
F. H. ASHHURST.

NAINI TAL: }
The 8th October 1880. }

Extract from the Records of the Geological Survey of India, Vol. XIII, Part 4, of 1880.

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NOTE ON THE NAINI TAL LANDSLIP (18TH SEPTEMBER 1880), *by* R. D. OLDHAM, A.R.S.M.,
Geological Survey of India.

On Saturday, the 18th of September, at half past one in the afternoon, after more than thirty-six hours of heavy continuous rain, a portion of the hill forming the north-east slope of the valley of Naini Tal fell, sweeping away several houses, and causing the death of 43 Europeans and more than 150 Natives.

Briefly told, the story of the slip is this : On the morning of the 18th, at ten o'clock, a small slip occurred behind the Victoria Hotel, burying part of the buildings in which were some Natives and a European child. A party of volunteers and a working party from the dépôt were soon on the spot, but after a while the greater portion of the latter were withdrawn. After rescuing all that there seemed any probability were still alive, they found that the house was in danger of being washed away by a stream of water, and so turned their attention to the diversion of the stream ; and while engaged in this, the great slip came down and overwhelmed them. It is possible that the wash of this diverted stream may have directly contributed to bringing down the landslip, but it seems to me very improbable that it had any such effect ; at most it can but have hastened the catastrophe by a few hours.

The part of the hill which has fallen extends up to the old Government House, marked as such on the map. From here the western boundary runs down a little to the east of Marshall Cottage and Charlton ; the eastern boundary passes down just to the east of the Victoria Hotel. The mass of débris which has fallen from the hill extends over the level ground at the head of the lake, as far as the Assembly Rooms, of which but the southern end remains standing.

The slip, as it at present stands, stretches in a long, gentle slope, which, omitting irregularities of surface, is not more than 15° up to where the old Victoria Hotel stood ; from there it rises in a steep slope of 25° or so, and at the top comes a short space nearly vertical. This steep slope is formed by the small slopes of drier débris which fell after the great one. The total length of the slip, measured horizontally, is about 600 yards, of which over 300 are occupied by the gentle slope, and the remainder are more or less steep.

The hill on the north-east of the lake consists of more or less imperfectly cleaved clay slates, occasionally showing signs of an initial metamorphism into schist, but for the most part a simple clay slate. The dip is very disturbed, and varies much in different parts in close proximity to each other ; but the general dip is to the south-west. The rock also is traversed by very numerous joint planes, which cause it to split up into innumerable fragments under the action of the weather.

Although the whole of the ridge bounding the Naini Tal valley on the north-east is practically one as regards its internal structure, yet, superficially, the south-east portion is very different from the north-west. Looking from the head of the lake, or, still better from near the old Government House, one cannot fail to be struck by the difference of profile ; towards the lower end of the lake the hill sweeps down at an even slope of about 25° from almost the top down to the level of the lake, while nearer the spot where the landslip took place there is a peculiar bulged appearance of the hill, which makes the slope steeper near the bottom than it is higher up, being occasionally, as above the Mission premises, as steep as 35° .

These two areas can be recognised on the map ; the even slope near the lower end of the lake is drained by innumerable channels running almost straight down the hill, while on the bulged portion the streams are fewer and their courses not nearly so directly down the hill.

The cause of this bulged appearance I take to be as follows : By the action of the weather the face of the hill gets covered with a greater or less thickness of decomposed rock, which, as already explained, weathers into a mass of small fragments. The rain water, which obtains access to the interior of the hill, for the most part keeps in this decomposed layer and flows down at a short distance from the surface, passing out again lower down in the springs which exist in numbers over this hill, and a large part doubtless percolating downwards reaches the lake without coming to the surface. The presence of large quantities of water among this decomposed rock must, by making it more mobile, assist in producing that phenomenon which is seen in any mass of *débris* lying at a slope, whether it be wet or dry, namely, the gradual passage of such *débris* down the slope under the influence of gravity ; that some movement of the *débris* down the slope takes place after heavy rains seems certain, as is shown by cracks appearing in the surface of the hillside, the lower side of which subsides slightly. Now on a level surface the action of gravity can have no effect in producing any motion, while on a slope the force tending to produce such motion varies directly as the resultant of the vertical force of gravity acting directly down the slope, that is, it varies as the sine of the angle of inclination. Suppose, then, an even slope passing near its base into level ground, and that slope covered with *débris* ; the *débris* slides slowly down the hill, but on the steeper parts of the slope it must do so faster than near the bottom, where the slope is less and there is the resistance of the *débris* lying on the level to be overcome, which can only be done by a *vis a tergo*, an impulse from behind. The *débris* coming slowly down from above and meeting with this obstacle gradually accumulates till it causes a bulging of the slope towards its base, which goes on increasing till the lower part of the hill is so steep that, to use a colloquial phrase, " it is touch and go " whether the hill can stand or not ; then a burst of rain heavier than usual comes, the head of water is increased, the force of the water flowing out near the bottom is increased, it begins to wash away the *débris* near the bottom till the support being removed from below small slips begin to fall ; then a few larger, and finally comes the great slip, which brings down the outer crust of half the hillside, leaving a precipitous border round that part from which it has come ; finally, the great slip is followed by smaller ones, which leave the hill with a pretty uniform slope from top to bottom for the whole process to begin again. Such I believe to be the history of one of these landslips where there is no stream cutting at the base of the hill ; where that is the case, slips may be formed at any time by the cutting away of the foot of the slope.

The slip under consideration has followed very much the course pointed out ; the bulging had reached the critical point : all through last rains small slips occurred ; on the 18th a larger one fell, shortly to be followed by the great landslip, which was itself followed by one or two minor ones, though the process of smoothing down the slope has not yet been completed.

Applying this hypothesis to the determination of the question of how much of this same ridge must be pronounced as unsafe and liable to slippage, we must condemn the hillside from a line running upwards from the Bank House to a similar line running down from a little to west of Fairlight Hall, it being all more or less bulged ; of this, that part extending from the old landslip to the stream flowing down to the east of the Mission premises must fall in a few more years, but, with this exception, a judicious system of revetment of the torrent

beds and a complete system of drainage of the cleared sites will do much to prolong the existence of the present hillside.

As regards the slopes below Cheena, there is but little chance of such a slip taking place: these slopes are the talus of the steep scarp of Cheena, and are continually receiving additions from above, and though on them there may be danger from the large boulders which occasionally fall from Cheena, the slopes pass off so gently into the comparatively level ground at the head of the lake, and are, moreover, concave rather than convex in profile, that I consider the probability of any of them forming a large slip to be very small indeed.

Many interesting points might doubtless be elicited as to the manner in which the mass moved, were there any satisfactory accounts of eye-witnesses; but such there are not, and for the same reason that it is almost impossible to get a trustworthy account of a great earthquake,—the thing is so sudden and so awful that none but trained observers can keep their presence of mind necessary for making those exact observations which only can be of any scientific use.

The only points which can be satisfactorily established are, that the whole fall must have been over in less than quarter of a minute, and that the Victoria Hotel and Bell's Shop (Racquet Court) were carried along some distance before they fell; in the latter case there is proof of the fact, inasmuch as the ruins are now some yards from the spot on which the building originally stood. As the ground on which both these buildings stood consisted entirely of *débris*, locally known as 'shale,' which must have been saturated with water after the heavy rains which for thirty hours and more had been pouring into it, it is not surprising that when the wreck of the hillside was precipitated on to it, it should yield as a semi-fluid body would do and float the buildings for some little distance before the actual slip overtook and overwhelmed them. That the whole mass must have been in a semi-fluid state from the amount of water contained in its substance, is shown by the low angle at which it now lies, and by the fact that those who ventured on to the fallen mass immediately after its fall sank up to their knees in the slush, as it has been described.

Doubtless the point of most scientific interest in connection with this landslip is its bearing on the theory of lake formation by landslips. One of the principal objections raised to the supposition that the barrier at the outlet of Naini Tal, for instance, can be formed by a landslip is, that those slips, "possessed of most mobility, from the greater fluidity of their composition, are in the precise ratio of such fluidity least capable of * * * bearing upon their surface craggy masses of rock, such as I should term erratics" (*supra*, p. 165). The examination of the landslip under consideration disposes of this objection; for though most certainly such "craggy masses of rock" were not borne on the surface of the semi-liquid mass, yet there were numbers such floated in its substance, many of which now show at the surface, several being 9 or 10 feet in length exposed, and I have no hesitation in saying that were this landslip on a larger scale—for it must not be forgotten that compared with several others in the hills around it is insignificant in size—and left untouched by the hand of man, it would, when cut into by rain and streams, show many, if not all, those features which are supposed to be especially characteristic of a moraine.

As to the question whether the barrier of the Naini Tal basin is a landslip or a moraine, I shall not here enter into its discussion; this, however, I must say, that the profile of the slope to the east of the outlet bears every appearance indicative of a large landslip having fallen there. On the hillside there is no bulging, but a straight sweep down to a comparatively level terrace, through which the stream forming the outlet of the lake has cut down for some distance. Whether the lake was formed by the landslip, or whether this was subsequent to

the formation of the lake, I am not prepared to assert dogmatically, but this I believe, that in past times there has been a great landslip from the slopes of the Kalikhan, and that on this old slip are placed the hospital and convalescent dépôt.

The recent slip shows clearly that a large landslip can extend across and fill up a valley, and at the same time may show that mixture of rocks of all sizes which forms one of the chief features of a moraine; and it is not improbable that, under favourable circumstances, it might resist the wash of a stream over it and so form a permanent lake. In the case of Mulwa Tal, one would certainly suppose from the look of the ground that if its existence is not due to a landslip, yet the level of the water must at one time have been raised some twenty or thirty feet higher than it now stands, by a great landslip which has undoubtedly fallen from the hills to the east of the outlet in times which may not date further back than one or two hundred years, and are certainly later than much that geologists would speak of as recent.

But if a lake is to be formed by a landslip, it must not merely be one of those which are everywhere to be seen, caused by the cuttings of a stream into the base of the slope, but rather one of those which take many years and even centuries preparing, as has been the case with this small one at Naini Tal, and which when they fall do not come down in a stream of fragments, but with one great rush, which would carry them right across the valley and raise the surface to such a height that, by the time the dammed-up water reached high enough to overflow, the débris would have had time for the water mixed with it to drain off somewhat, and would have settled down sufficiently to withstand the wash of the stream running over it. Such cases have been known, but the dam has always given way; yet it is not inconceivable that in some cases which have happened in that remote past of which we have no knowledge but what is written in the rocks, some few barriers so made were able to stand and form what are now known as the Kumaun Lakes.

Yet it must always be kept in mind that no theory which can be put forward to account for their formation can be considered satisfactory, unless it also accounts for the absence of similar lakes in other parts of the Himalayas; for it is no explanation to say that this is due to the smallness of the drainage areas which supply the lakes, and the consequent small size of the streams flowing from them, for other portions of the Himalaya are not devoid of small streams, nor can that which flows from Mulwa Tal be called small.

NOTE.

My youngest colleague, Mr. Richard D. Oldham, happening to be in Kumaun at the time, I asked him to give me an account of the disastrous landslip at Naini Tal. The foregoing excellent paper is the result. It is Mr. Oldham's first contribution to the publications of the Survey; and the accurate observation, strict reasoning, and good form it evinces, give high promise of fruitful work to come.

It will not be amiss, on an occasion of such vital interest, to add a few remarks that occur to me especially as suggested by the report of the Committee appointed by the Local Government to enquire into the condition of the Sher-kanda hill, a copy of which was sent to me officially at about the same time, "for information." The portion of the hill marked by the Committee as presently dangerous corresponds very nearly with that indicated by Mr. Oldham; but their observations would seem to have a wider extension, and to involve a larger area of affected ground. Mr. Oldham was only there for a few days, on his way to take up work for the season in Sirmur, and he probably confined his attention to the particulars of the event under discussion. I did not instruct, or expect, him to do more than he has done, the Survey not having been called upon for an examination of the ground.

It would be understood from the report of the Committee that the surface cracks, justly regarded as symptomatic of failing ground, occur much beyond the area condemned, also the Committee's description of the geological structure of the hill would be taken in the same sense; it is as follows:—"To the ordinary observer the hill seems to consist of a core of rocky shale, the dip of the strata being to the south-west, at an angle varying from 30° to 50° . This core is covered by varying thicknesses of disintegrated shale and mud, in which are scattered boulders of limestone, and occasionally of trap, the whole of this crust being in its natural state bound together by a luxuriant growth of grasses, shrubs, and trees." It does not appear that this is thought an unusual composition for the crest of a steep ridge, 7,000 feet in elevation. As applied to the dangerous ground, it would exactly suit the conditions described by Mr. Oldham—the decomposed clay slate creeping down the hillside, carrying with it blocks detached from the occasional outcrops of harder rocks. It is scarcely possible under the circumstances that such a crust could be rock *in situ*, whether an enveloping shell of some unconformable deposit, or a condition, however decomposed, of the rocks described as the "core." It can, in such a position, only have been formed from these latter by displacement, being either the remains of an old landslide, or the material in order of active preparation for a slip to come. In the former case the ground may be perfectly safe, in the latter it would be at least doubtful. If, then, this description applies extensively, as might be inferred from the Committee's report, the matter may be worth further consideration; for the premonitory "bulging," so effectively detected and described by Mr. Oldham, may not be a necessary part of the performance. In the case of the condemned area, that feature is reasonably ascribed to the resistance so well presented at the base, where the slope tails off into the flat ground at the head of the lake; but where this condition does not obtain, as along the lake shore to the south-east, a crisis might occur without that visible warning, although there would be every reason to expect it to be mild in comparison to what happens when an accumulation has occurred by bulging.

Altogether, it is by no means unreasonable to hope that the practical judgment of the Committee may be well founded—that, except in the prescribed ground, security can be insured by proper precautionary measures. Mr. Oldham has expressed the same opinion.

In the 30th September number of *Nature à propos of the Naini Tal catastrophe*, there is a picturesque description of landslips in general. The writer is evidently thoroughly informed upon the subject he treats of, although grievously in error regarding the geological condition of Naini Tal, which is described as on the tertiary rocks. This mistake is unaccountable; for the place is clearly shown on our geological sketch map of India as inside the Sub-Himalayan boundary. From the foregoing notice it will be plain that the Naini Tal slip cannot be classed with any of the particular cases mentioned in *Nature*. I have seen no fact to suggest that there is any predisposing plane of stratification connected with these slips. The contrary may, indeed, be affirmed, for although the general dip of the strata is stated to be south-westerly, the frequent contortion these slates have undergone almost forbids the supposition of a continuous surface of any extent in a fixed direction, such as is implied by the action in question.

The Naini Tal landslide of the 18th September was in fact, except on the score of mischief, a comparatively small affair, considerably less in magnitude, as mentioned in Mr. Oldham's paper, than several others that occurred at the same time in the Kumaun hills.

H. B. MEDLICOTT.

Dated Naini Tal, the 11th October 1880.

From—H. C. CONYBEARE, Esq., C.S., on *Special Duty*,
To—Secretary to Government, N.-W. Provinces and Oudh.

SIR.—In obedience to the orders conveyed in your No. 2983 (General Department), dated 5th instant, I have the honor to submit a report on the late landslip at Naini Tal. Accounts more or less directly bearing on this calamity have been or are being prepared in several departments—by an Engineering Committee, by Mr. Oldham of the Geological Survey, and by two Military Courts of Inquiry. While these other narratives regard the question from certain special or professional points of view, the present essay will confine itself to a general sketch of the facts. A list of authorities is appended.* For though well acquainted with all the localities and some of the persons hereinafter mentioned, the writer was himself absent on leave when the landslip occurred.

2. The scene of the disaster can be very briefly described. Naini Tal, the tarn of the goddess Naini, is an oblong sheet of water almost surrounded by woody hills. Though somewhat irregular in outline, it has four very well defined corners; and for purposes of simplicity may be considered a parallelogram stretching from north-west to south-east. Its dimensions are irrelevant. But more distinct ideas of its appearance may be formed from the statement that its circuit is about $2\frac{1}{2}$ miles and that its encircling mountains rise abruptly to between 800 and 2,000 feet above its surface.

3. On its north-western side the lake was flanked by a small level space which, from its great variety of diversional uses, has been justly called "a compendium of games." About this playground were grouped several buildings, of which four at least must be especially mentioned. On the very verge of the water rose the assembly rooms, which included under one roof a library, a theatre, and floors for dancing. Further north, thrusting its red roots into the lake, stood a willow grove, which shaded the temple of Naini. West of the temple inland lay the shop of Messrs. Bell and Son, once a racquet court of the old and too commodious pattern common in India. And still further west, in what was known as the public gardens, nestled the orderly room of the Volunteers.

4. Northwards from these buildings and the northern corner of the lake mounts the slope which culminates in the peak named Alma. At first this slope is a mere beach of shingle and other *detritus*; and, like beaches in general, has no very sudden gradient. But after a few hundred yards of upward travel, we reach the hillside proper and the angle of inclination rises to 35° or 40° . Nor, before the fatal cataclysm, was the difference of angle the only difference between these two portions of the ascent. So far as affected by the landslip, the hillside had no buildings and much vegetation; the beach had little vegetation and some buildings. These buildings were in almost every case parts of the Victoria Hotel.

5. But to make this description clearer are subjoined a map (A) and a photograph (B) of the whole locality.

6. The structure of the hillside renders it singularly vulnerable to the attacks of water. On this shore of the lake there is not, as opposite, any trap. The rock consists of clay-shale interspersed with limestone boulders. The shale has a more or less defined cleavage, and numerous cross joints make its division into minute segments easy. Towards the surface it has weathered into a very crumbling and friable mosaic, which, when denuded of vegetation, will literally not stand washing. The torrents which scour that surface after heavy rains have little difficulty in

* Appendix II.

gnawing fresh ravines or eating out fresh boulders. But though a boulder may sometimes slip down the hillside, marking its course by a trail of unfurled ground, little harm is thus effected. What happened in the present case was a dislocation of the whole hill crust, shale and boulders together. Wet-weather springs had probably sapped the foundations of that crust for years. There is reason to believe that, at the time of the catastrophe, considerable percolation was taking place between the gravelly hide of the rock and its harder interior. A stream hitherto unknown may now be seen trickling down the exposed face of the latter. Immediately after the landslip several such streams were visible.

7. Under such conditions the danger of a landslip was of course foreseen. *Rien n'arrive que l'imprévu* is not an epigram which receives much support from the late misfortune. As early as 1860, writes Major Garstin, the Victoria Hotel was considered unsafe. In 1866 occurred a slip, wherein originated the ravine and stream visible on the left or west side of the photograph just given. This, the first of such mishaps within living memory, left a raw abrasion in the scalp of Alma, hitherto covered with oak, wild indigo, and ferns. For more than a decade no further alterations of much importance took place. But last year (1879) a rather heavy slip enlarged the head of the same ravine. Last year, too, Dr. Walker succeeded in preventing the sale, for building purposes, of some land on the since excoriated hillside. That the peril of placing houses on such a site was acknowledged, is perhaps proved by the fact that no houses were either before or after placed there. The Victoria Hotel, it will be remembered, was on the beach below the hillside.

8. During the present year Dr. Walker's watchful eye, rendered more watchful by his possession of property in the neighbourhood, noticed that the whole hill crust had sunk some six inches from a crack in the lofty road known as the Upper Mall. Warning was given, both by him and the Chief Engineer; and the Municipal Committee decided to revet the ravines. But though a slip was foreseen, its magnitude was beyond all forecast. The measures undertaken were necessarily insufficient. And it may be doubted whether any prescience or skill, money or labour, could at that eleventh hour have averted the downfall.

9. Two predisposing causes are mentioned as having indirectly produced or hastened the crash. It is said that on the fatal 18th September a slight earthquake shook the station. At 10 in the morning of that day Mr. Fleetwood Williams felt in the assembly rooms the nauseous sensation often excited by such convulsions. He noticed that the lake had assumed a peculiar greenish chalky hue which was never imparted by mere influx of muddy water, and never seen except after earthquakes. Tremulous shocks were perceived at different hours on the same date by Major Byam, Mr. Holderness, and a few others. But the convulsionist theory meets with less general favour than another which asserts that the excavation of fresh building sites on the ridges of the hill had permitted the crust to become overcharged with water. In any case water was to blame: and of water there had been a surfeit.

10. For during the two days preceding the catastrophe the windows of Heaven had in truth been opened. Rain began falling on the afternoon of Thursday, the 16th. It fell without ceasing until the night of Friday, the 17th, when, according to the gauge of the late Mr. Noad, there was a precipitation of 9 inches. It is officially reckoned* that during the 40 hours ending on the early morning of Saturday, the 18th, from 20 to 25 inches had fallen; but in different parts of a large hill station such figures necessarily vary. The downpour continued throughout the 18th up to the time of the landslip. It is not altogether foreign to the subject to add that it continued for about 24 hours afterwards. Long before dawn on Saturday several brown torrents were brawling down the hillside, to cut their way through the shingly beach below.

* N.-W. Provinces and Oudh to India, Home Department, No. 2852 of 1880.

11. At half-past five A.M. Captain Harris, the proprietor of the Victoria, was already at work attempting to divert the streams which threatened his hotel. He was still thus occupied at ten, when a tree, whose roots had been exposed by the water, fell on the range of servants' houses behind that building. Some of the houses subsided, burying with a farther or nearer approach to completeness a man, a woman, and a child. But the tree continued its downward course, only stopping when it had shattered the wall of three rooms in the hotel itself. Beneath the ruins were embedded the little boy and the native nurse of Mrs. Francis, then stopping in the hotel. Captain Harris at once conveyed the news to Mr. Leonard Taylor, in magisterial charge of the station; who, with Road Overseer Mr. P. Morgan, about four policemen, and a dozen Ladakhi labourers, hastened to the spot. Their first efforts were directed towards the extrication of Mrs. Francis' child. Meanwhile the alarmed residents and their servants were quitting the hotel. Of the former there seems to have lingered only Colonel Taylor and the Revd. A. Robinson, who had between them four attendants. The hotel servants, some 25 in number, took refuge in Captain Harris' private residence, a building afterwards half erased by the landslip.

12. The minor accident just described has sometimes been styled "the first slip." It is occasionally said to have overwhelmed, amidst the ruins of the out-houses, some 20 or 30 natives. The tree of course dragged a considerable tonnage of moist and gravelly shingle with it. But from the statements of Captain Harris and his brother-in-law, Mr. Chapman, it seems that no displacement sufficiently general to be called a landslip occurred. Of the natives who were thought to be engulfed, all except four had found a temporary respite elsewhere.

13. The warning luckily given by this first ruin was not the only warning. To hasten the exhumation of the entombed and the removal of *débris*, it had been thought advisable to obtain aid from the Military Convalescent Dépôt. The result was the arrival in detachments of some 110 or 120 British soldiers, officered by Captain Balderston, Lieutenant Sullivan, and Second-Lieutenants Halkett and Carmichael. As a volunteer, to assist the brother subalterns with whom he was staying, had come Second-Lieutenant Robinson. Amongst many others who sooner or later lent their aid were Mr. Noad of the Police* and Surgeon-Major Hannah. Present also were Messrs. Tucker and C. Morgan, clerks in public offices; a railway employé called J. Shiels; and three brothers, his namesakes, but not his kinsmen, who are known to have taken an active part in the extrication of the man first crushed. Now while most of these were busily digging there appeared a second premonitory sign, which, had they been less engrossed in their work, might have attracted anxious notice. It became needful, writes an engineer† who was temporarily present, to divert a stream which had borne down on the hotel. "The water in its new course cut away the base of the hill. At one time a living torrent of earth, that had no appearance of water save only in its wavy motion, went past us: apparently in a stream of its own, and nearer the base of the cliff than the water torrent. But to the best of my knowledge none thought of a landslip."

14. And so till half-past one the workers at the Victoria worked on. By that time most of the buried bodies having been unearthed, most of the fatigue party had been ordered back to barracks; but all the officers, with at least a dozen of the non-commissioned officers and men, remained. Let us for a few minutes quit them to descend the beach and visit Bell's shop. This too had been threatened by torrents, and to turn their courses Mr. W. Bell, his assistant Mr. Knight, Sergeant Instructor of Volunteers McEwan, and others had toiled for hours. But they had just dismounted for luncheon. Messrs. Bell and Knight returning to the shop, and Sergeant McEwan being last seen at the back of the orderly room.‡ When the two former

* Statement of Mr. E. MacLeod.

† Mr. Mason.

‡ Mrs. Gray's statement.

entered Bell's, they found there, besides others whose escapes will be noticed hereafter, the following persons :—Captain Haynes, who had quitted the Victoria for what he imagined a safer place of retreat; Messrs. Moss and J. Drew, assistants to Mr. Bell; a little boy named Gray; the baby girl of Mr. Knight; and about 20 native servants belonging to the shop or its inmates. Vague rumours have murmured that 40 native tailors perished in the building. The fact is that there were but 15 tailors on the establishment, and that in the disorganization produced by rushing waters and alarms from the Victoria, these were all ordered out of the house several hours before.

15. In or around the neighbouring orderly room were Sergeant McEwan; a native messenger and his two brothers; and four servants whom the Commandant of the Volunteers had sent to assist in defending that building from water. Within the precincts of the neighbouring temple were gathered seven men of more or less priestly character, and a mason who had been employed upon repairs. The assembly rooms sheltered Major and Mrs. Murphy, Mrs. Turnbull, Captain Goodridge, and the librarian Private Farrance. These had all walked thither, and were therefore unaccompanied by any native litter-bearers (*ghampāni*). But within the rooms themselves were two native messengers and the son of the native watchman.

16. At about twenty minutes to two, through the dripping of the rain, rose the sound of crackling trees. Some oaks on the hillside, about 400 feet above the Victoria, were observed falling forwards. A boulder or two descended, and a shout of "Run for your lives!" was heard ringing up from the hotel. It was followed by a noise which to those near suggested the rumbling crash of thunder, and to a witness not far distant the hoarse roar of cheering for some person rescued. By others on the ridge above and on the south-eastern edge of the turn this noise was not heard at all; but it meant that the hillside had fallen. In less than half a minute the last stone had splashed into the lake. Several great waves rolled down its surface, whilst a cloud of light brown dust concealed its north-western side and the site of the Victoria from view. As to what had happened in the interval no two witnesses are exactly agreed. For the close observation of details both the time and the mood were wanting. When the curtain falls it is too late to count the buttons on the coats of the players.

17. But here are some extracts from the statements of selected eye-witnesses :—"With one fell swoop and awful crash," writes the Revd. D. W. Thomas, "the Victoria Hotel, Bell's shop, the assembly rooms, and a throng of human beings were almost instantly buried beneath the rocks and the lake. The hotel moved forward, foundation and all, at least a hundred feet before it collapsed; and Bell's shop about the same distance. When the slip commenced there were a large number of natives and five or six (British) soldiers passing along the Mall below; most of whom were buried beneath the shale and rocks." Mr. Thomas adds that the Victoria and the Hindu temple were carried directly into the lake. The only trace of the hotel main building is the fragment of a pillar; but this lies on the playground, as far distant from the lake as any part of the *débris*. Remains of the temple and its occupants have been dug from the edge of the water.

18. Sub-Engineer Mr. W. Gilbert says :—"I was startled by a thundering noise behind me, and on turning round saw that the Victoria Hotel had disappeared. An immense, dark, moving object was passing over its site, reaching the lake in a very, a very short time, carrying everything before it, and crushing up mighty trees like match-sticks. For about a second of time Bell's and the assembly rooms were overshadowed; and then there was a tremendous crash, followed by a splash in the lake. The mass of mountain which had detached itself came down with such velocity that for the moment the impression on my mind was that a huge promontory from 30 to 40 feet high had leapt out from the hillside into the lake,

disappearing a few seconds after the awful splash. I am sure I could not have run over twenty paces on open ground and in the best form within the same time."

19. The Rev. N. Cheney, who was standing about 20 yards from the course of the slip, was startled by hearing above a noise which seemed "to mingle the report of a muffled explosion with what sounded like a high-toned piercing cry. The trees shook and writhed; the hillside burst: the whole mass fell in a headlong avalanche, and rushed down the slope towards the Victoria Hotel. The bursting of the hill was with an upward as well as an outward leap, as if some interior power had accumulated until it could no longer be confined. The hotel was not crushed from above, but was struck near its foundation; and fell back on, and was carried forward by, the advancing slide. Its roof appeared to turn upside down; for the rafters were for an instant plainly visible in a vertical row. A cloud of dust obscured from view the destruction of Bell's shop. I was nevertheless able to discern that the central column of shale, in which the greatest velocity and power were exhibited, passed over the Mall at the entrance gate of the hotel, and thence in the shortest line plunged into the lake. It is, my judgment that the time from the bursting of the hill to the descent into the lake was not more than 8 seconds."

20. "I heard," writes Major Macmullen, "a crashing and rustling sound, together with some shrieks. I ran into the verandah, when I saw a huge mass of *débris*, shale, &c., rolling down like a wave on to the assembly rooms; and a portion of it, striking the end of the building, precipitated it into the lake. I am pretty sure I saw several persons swept into the lake." "Looking up from my writing," says Colonel Dalmahoy, "I saw a large cloud of dust just below old Government House. Of course I knew at once what it meant; and I ran into the verandah just in time to see the Victoria Hotel swallowed up. I say swallowed up, because it was buried at once, disappeared in a moment: no part of it was visibly carried along. After passing the Victoria the avalanche spread out somewhat more. In a few seconds it reached Bell's shop, which appeared to rock to and fro for a second, and then collapsed like a house of cards. The whole mass was then driven on to the assembly rooms, which simply disappeared into the lake. I saw that there were people about, both at the Victoria and down below, who had been swallowed up, but could not distinguish who they were."

21. Taking as his data that its average breadth was 1,000 feet, its average height 400, its average depth or thickness 56 feet, and its weight per cubic foot 100lbs., Colonel Brownlow, R.E., reckons that the falling mass equipoised 1,000,000 tons. The figure is like an astronomical distance, more easily uttered than realized. But almost exactly the same arithmetical conclusion has been attained, on slightly different premises, by Mr. Robert Smeaton, C.S., who made a separate investigation. Mr. Smeaton computes that travelling over such ground, the mass must have reached its goal in about 11½ seconds. It has been described as semifluid; and, containing as it did much water and much finely comminuted shale, must certainly have had a rather gruelly consistency. Spreading fanwise as it fell, like a stream of lava, it first encountered the Victoria; and the only standing vestige which it left of that inn was the eastern half of Captain Harris' private residence. Having once indented the beach below the hillside, the slip, according to one theory, pushed the former surface of the ground before it. Hence the perhaps lengthy journey of the hotel before its collapse, as described by Mr. Thomas. Though apparently cleft in half, Bell's shop was certainly carried some seventy yards before it subsided; and the temple a rather shorter distance. These two latter buildings came into collision with the assembly rooms, driving into the lake about three-quarters of that pleasant resort. The orderly room lay on the western skirt of the landslip's course; and, to judge from the position in which the battered rifles of the volunteers were discovered, must have been dashed out westwards.

22. But when it reached the middle of the playground, the earth-stream ceased to flow. The places where it received check was marked by a mingled and mangled trophy of shattered rafters, broken boughs, iron-roofing building stone, plaster, rags, coverless books, and other ill-assorted fragments. Between this heap and the head of the slip rose and rises a fairly smooth slope of shale-shingle, whose bare monotony is broken only by an occasional boulder or uprooted and half-buried tree. But the annexed photograph (C), taken from the same standpoint as the first, will show far more eloquently than any description how complete has been the ravage. A detailed estimate by Mr. Kilvert reckons the loss of property at Rs. 2,55,500, that is, let us say, at £21,290.*

23. The destruction of life is a subject that cannot be dismissed with equal brevity. The dead and missing muster 151, of whom 43 are British or Eurasian. For 131 of the whole number preceding paragraphs have accounted. Thus, at or around the Victoria are known to have perished 30 Europeans,† of whom more than half belonged to the fatigue party; 4 natives killed or at least detained by "the first slip"; about 25 hotel servants, who were swept away with the western half of Captain Harris' house; 4 private servants; and 8 other natives, policemen, labourers, and an orderly, who at the time of the catastrophe still remained with Mr. Taylor. Here, then, where the mortality was greatest, was an ascertained loss of 71. The loss was perhaps greatest in quality as well as in number. For here the station was deprived of an able and most courteous ruler; the lake of an accomplished stroke; and the racecourse of its best rider. In the untimely extinction of dashing and generous spirits like Messrs. Taylor, Noad, and Sullivan, Her Majesty's services have suffered casualties which are more easily deplored than repaired. It is lucky that most of the hotel residents were at the time of the slip seeking shelter elsewhere; lucky that most of Mr. Taylor's labourers had followed Sir Henry Ramsay to the lower end of the lake. It should perhaps be added that further search for bodies in this direction is useless and even dangerous; useless, from the great depth of the deposit; dangerous, because interference with the natural slope of the loose shingle might bury the searchers themselves. A funeral service has been read over the supposed graves of those "sealed within the iron hills."

24. At the temple were overwhelmed as above shown 8 persons; at the orderly room 8, including one European. In the assembly rooms also were destroyed 8 lives, five of them English. The bodies of Mrs. Murphy, Captain Goodridge, and Private Farrance have been exhumed from beneath that fragment of the ruins which was not swept into the lake. At Bell's we have counted 26 persons who perished; and of these seven were Europeans.‡ Some of those killed were still living when lifted. Found at once but found dead was Mrs. Gray's son, whose watch, stopping at a quarter to two, confirmed other evidence in marking the time of the landslip. The other bodies recovered, in some cases from beneath the ruins, were those of Captain Haynes, Mr. Knight's baby, Messrs. W. Bell, J. Drew, and Moss. It has now been shown in what manner most of the missing persons died. Of those, however, who were killed while passing along the

* This estimate does not, however, include the private property lost by hotel residents. Nor does it include the bathing sheds, which were destroyed by the joint action of torrents and of the waves which the descending landslip stirred up on the lake. In the photograph (H) these sheds may be seen standing just south of the assembly rooms.

† Colonel Taylor.
Revd. A. Robinson.
Dr. Hannah.
Captain Balderston.
Messrs. { L. Taylor, C. S.
Noad.
Sullivan.
Halkett.
‡ Captain Haynes.
W. Bell.
Messrs. { Knight.
Moss.

Messrs. { R. S. Robinson.
Carmichael.
4 Non-commissioned officers,
8 men.
Mrs. Francis' child.
Mr. Tucker.
Messrs. { O. and P. Morgan.
A. C. T. and J. Sheils.
Mr. J. Drew.
Mrs. Gray's boy.
Mr. Knight's girl.

roads nothing exact can be ascertained. They did not appear on the scene till after most of the survivors had quitted it. But on a day of streaming rain and streaming paths the wayfarers were probably few. The state of the roads must, moreover, have hindered riding; and in the police returns of mortality but one person is entered as a groom (*sais*).

25. The swell excited by the sudden plunge of hillside on lake was responsible for three more deaths. Rising with a height and violence which left fishes flapping well inland,* which swamped or wrecked almost all the boats of the station, the waves swept downwards to the south-eastern side of the water. Here the marginal road was already flooded; and Lieutenant-General Sir Henry Ramsay, with some native labourers, was attempting to drain off the inundation. On the approach of the first great wave the alarm was given. Sir Henry and many others, though at one time waist-deep, succeeded in reaching safety on an ascent in the road: but several British soldiers and natives were swept into the torrent which relieves the lake. Of the former one, and of the latter two, were killed. The body of Private Hayes was discovered two days later some distance down the cascade.

26. The narrow escape of Sir Henry Ramsay's party was only one of many which deserve passing mention. Accepting the short warning of falling trees and falling boulders, several witnesses had time to escape before the main body of the slip descended; but some other survivors were less fortunate. Mr. J. Walker had almost reached the Victoria, with a view of offering his assistance, when the slip began. Rushing athwart its course he was overtaken and rolled some distance by the outer edge of the tumbling mass. Covered at first with loose shale, his body was at length partly exposed, and he was afterwards extricated without a bone broken. Mr. E. MacLeod had just left the hotel with the Shiels and Mr. Tucker. The slip swept them up as they ran; and Mr. MacLeod found himself carried, in front of a protecting plank, to the very goal of the earthy flood. Though more than half buried in *débris*, he too was rescued almost uninjured. Lance-Corporal Bonwell was one of those ordered back to barracks by Captain Balderston. He had reached the road between the Victoria and Bell's when he heard the crash, and was almost instantly swept into the lake, whence he escaped by swimming. Also into the lake was hurled unhurt a native servant of the assembly rooms, who was effecting some repairs on the roof of that building.

27. Mr. A. Drew was startled out of Bell's shop by the clatter of the slip; and seeing a great cloud of dust in the direction of the Victoria, ran for life across the playground. He was overtaken and thrown by the now almost spent mass, from which he was afterwards released with a broken collar-bone. Mrs. Knight, Mrs. Gray, and Miss Shaw, all assistants to Mr. Bell, were in the upper storey of the same building; and with it were carried into the middle of the playground. When the shop collapsed, they were more or less protected by its roofing; but Mrs. Knight was severely injured, and Mrs. Gray's left arm was broken. Having first heard what she thought was thunder, the latter imagined that she had been struck by lightning: a confusion of cause and effect not unnatural in the agitation of the moment. Since the day of the disaster none of those injured has died; nor are further deaths to be expected. A detailed list of the slain will be found below.†

28. Such is the brief outline of a tale which needs no sensational adjectives to increase its sadness. The loss of friends has perhaps led many to attribute almost national importance to a merely local disaster. To argue that more lives have been lost than were lost with Cavagnari is to compare two events that do not admit of contrast. Nor, even amongst local afflictions, could this landslip claim the first rank. Beside the loss of the *Princess Alice* pleasure steamer it was but Ben Nevis beside Mont Blanc; and the Press has been prudently sparing of

* Mr. Ashhurst's statement.

† Appendix E.

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* Mr. Asdhurst's statement.

† Appendix I.

common place comparisons between the respective fates of Naini Tal and Pompeii. But that the calamity was at least as grave as a severe railway or colliery accident no one will deny. It may prove some consolation for a serious mortality to remember that almost all those lost died suddenly, in the execution of their duties; that some died in the unselfish execution of a duty which was self-imposed. Most men, perhaps, have at times wished to meet their end in the former manner.

29. The panic which rapidly thinned Naini Tal of its residents was not unnatural; but it has now had ample time to allay itself. When reason has triumphed over fear, the case may perhaps reduce itself to this:—That for once in the forty years of the station's history a notoriously weak portion of the hillside has been rendered fatal by an abnormal pressure of rain. For precaution's sake, the Engineering Committee will probably condemn as dangerous a few houses on the slopes of Alma and the neighbouring Sher-ka-danda. But, being written from the side of the hill first named, the assertion that many more are perfectly safe has at least the merit of sincerity. At the outside only four of the 209 English dwellings in Naini Tal must be unconditionally abandoned; while about a dozen more may be declared in need of engineering prophylactics. There remains the question whether slaughterous landslips may not again descend on the social centre of the station. The answer is that, scoured last month of its treacherous crust, the hillside can here threaten danger to no person at present living.

30. But "the whole place is a cemetery." That a certain number of bodies lies under the shale in a certain limited portion of the station is true; but the same argument might prevent people from taking houses near the churchyard. The silent and harmless presence of the gallant dead has seldom caused the desertion of villages in the neighbourhood of battlefields. Singing of an ancient town in these provinces a celebrated Eastern poet cries that the dust which shelters so many of the departed good is as salve to his eyes. Nor can it prove a ban against the Naini lake that both the gallant and the good have fallen beside it; or that its lovely brink is the last home of chivalrous gentlemen who in their deaths were without fear and in their lives without reproach.

16

No. 842, dated Naini Tal, the 25th September 1882.

From—J. R. REID, Esq., *Offg. Secretary to Government, N.-W. P. and Oudh,*
To—*Commissioner, Kumaun Division.*

IN reply to your letter No. 991, dated 19th September 1882, regarding the appointment of a Committee to report on the present state of Naini Tal, I am directed to convey sanction to the immediate assembling of a Committee composed of the following gentlemen :—

COLONEL FORBES, R.E., *Chairman.*

MAJOR GARSTIN.

MR. ASHHURST, C.E.

MR. PETMAN.

MR. BERESFORD, C.E.

One member of the Municipal Committee.

2. The Committee should report upon the character and apparent stability of the protective works, and their probable effect in ensuring the safety of the various properties which were considered unsafe by the former Committee, and also upon the general safety of the settlement and necessity for further protective works.

3. I am to suggest that the Civil Surgeon might be added to the Committee, with the incidental object of ascertaining whether the state of the drainage affects the health of that part of the station which lies in the basin. The flooding during the rains of Sukha Tal and its subsidence seem to merit attention from a sanitary point of view.

4. The special report on the financial condition of the municipality may be postponed until the Committee's report is received.

Report by Committee on the Naini Tal Settlement.

THE orders of Government in its No. 842, dated 25th September 1882, to the

address of the Commissioner of Kumaun, conveyed sanction to the assembling of a Committee, composed of the gentlemen named in the margin,* to report upon the character and apparent stability of the protective works at Naini Tal and their probable effect in ensuring the safety of the various

properties which were considered unsafe by the former Committee, and also upon the general safety of the settlement, and necessity for further protective works.

In the same orders it was suggested that the Civil Surgeon might be added to the Committee with the incidental object of ascertaining whether the state of the drainage affects the health of that part of the station which lies in the basin; that the flooding during the rains of Sukha Tal and its subsidence seemed to merit attention from a sanitary point of view.

2. The Committee of 1880 recommended the following measures :—

(1) All important ravines (see paragraph 19) should be revetted at intervals by strong cross-walls curved in plan, with well-guarded flanks (or wing-walls) built into the rock on either side. These walls should have considerable batter on the face, the courses being laid at right angles to the batter.

(2) All ravines should be lined where necessary with side-walls and strongly paved flooring laid in lime mortar, the channels being made large enough to carry at least double the maximum flood volume which has been known to flow down them up to date.

* Colonel Forbes, R.E., *Chairman.*

Major Garstin.

Mr. Petman.

Mr. Ashhurst, C.E.

Mr. Beresford, C.E.

One member of the Municipal Committee.

- (3) The cracks and fissures in the hillside should be carefully searched for, dug out as far as they can be traced, and refilled with well-rammed clay.
- (4) The platforms round every house, within the limits specified in paragraph 5 (or wherever the civil officer in charge of the station thinks necessary), should be covered with a six-inch layer of well-rammed clay or other material impervious to water. (When houses have been destroyed and abandoned, this might be done at the expense of the public and not at that of the proprietor.)
- (5) Gardens and cultivated terraces should be absolutely prohibited. Those that exist should be covered with clay and turf immediately, and existing lawn tennis grounds should only be permitted to remain on condition that similar precautions are taken to prevent the percolation of water into the hillside.
- (6) The further erection of houses or other buildings, quarrying of stone, and the excavation of terraces or platforms for any purposes whatever should be absolutely prohibited in the southern slope of the Sher-ka-danda hill within the limits specified in paragraph 5.
- (7) Special care should be taken to prevent injury from house drainage. Every house should have a gutter under the eaves and a catchwater drain round its base. The water from these should be carried in a masonry channel to the most suitable ravine, in which provision should be made for its reception.
- (8) House proprietors should be compelled to restore in an efficient manner all retaining walls which are bulged or cracked; and, further, to build such walls where they do not exist, and where their absence has caused or may hereafter cause slips in the hill above. Also, where there is any tendency to slip, to slope off the hill immediately above all retaining walls to an angle of 40°. This order should be binding on all proprietors, whether the houses or their estates are occupied by tenants or not.
- (9) The civil officer in charge of the station should be responsible for the maintenance in proper order of all watercourses in ravines and of all roadside drains. Special gangs should be employed during the rains to keep the drains free from obstruction and to repair damage immediately it occurs.
- (10) An honest, efficient, and trustworthy subordinate should be appointed as Inspector of buildings and drains, who should be under the sole orders of, and responsible only to, the civil officer in charge of the station.
- (11) All the arrangements for drainage of houses, road, and property, and the building of all revetment walls, and in short all operations which affect the safety of the station, should be carried out by order of the civil officer in charge through the agency of this Inspector. Where these necessary improvements are executed on private property, the house or land owner should be made to pay the cost. Private individuals should not be allowed to construct any drains, walls, or buildings without the written permission of the civil officer and the supervision of the Inspector.
- (12) All steep slopes should be turfed and planted; grass-cutting and grazing on the southern slopes of Sher-ka-danda and Cheena should be strictly prohibited.
- (13) The civil officer should have power to carry out the above and other measures for the safety of the station without reference to the Municipal Committee.

- (14) And finally, whatever sums are set aside by Government or the municipality for the maintenance and improvement of drains and roads should be at the disposal of the civil officer, to be expended by him, without reference to the municipality, in a regular and systematic plan, with the advice, when necessary, of the Superintending Engineer of the provincial circle.

These measures have all been carried out with the following exceptions :—

No. (4) has only been partially done, but generally platforms have been sloped off into drains, &c.

No. (5) has not been carried out, but gardens have been sloped off as above.

3. Amongst the houses specified as unsafe in 1880 were—

Cheena Lodge.	Bridge House.
Fairlight Glen.	Windermere.
The Pavilion.	Annandale.

As regards these, the present Committee are of opinion that the remedial and protective works which were made in 1881 have rendered these houses decidedly safer than before the works were constructed.

4. Springfield and the Club were mentioned in paragraph 23 of previous report. Regarding Springfield, the Committee are of opinion that although a wall had not been built the full height from the pakka drain of the ravine to the verandah of the house, the walls as built (with the grassed slopes) were sufficiently good to render the house safe for habitation, but the place should always be carefully watched. The necessity for dismantling this house has now been removed by the satisfactory protective measures since carried out in the Bara nadi and Glenmore ravines.

In consequence of the protective works having been so efficiently carried out the Club is also decidedly safer than ever before.

5. The "Omnibus," mentioned as not being quite safe in paragraph 25 of previous report, is still in the same state, nothing having been done to protect the steep hillside immediately behind it; but there is no appearance of any disturbance having taken place since 1880.

6. Regarding the Mayo Hotel, Bank House, and Morrison's shop, mentioned in paragraph 26 of previous report, the present Committee remark as follows :—The Mayo Hotel has been protected by strong revetment walls behind it, which must add greatly to its stability, but the Committee are still of opinion that the hillside between this building and Bank House is not to be depended on. The Bank House has, however, it is said, been already let for the next three years, which shows the confidence of the public in its position.

7. In addition the Committee have viewed the following houses and record their opinion :—

- (1) *Glenmore*.—It is agreed that this *site* is now safe, but that the existing house was originally very badly built and is not fit for habitation; it might, however, be entirely rebuilt with strong foundations, placing it well back on pakka ground.
 - (2) *St. Helens*.—This house may be re-occupied.
 - (3) *Rookwood*.—This house has been dismantled.
 - (4) *Alma House*.—
 - (5) *Alma Lodge*.—
- } Might be re-occupied.
- (6) *Snow View (called on the map Himalaya House)*.—This has been pulled down and entirely rebuilt further back from the edge of the site in a very substantial manner.

- (7) *Brae House*.—Has been rebuilt further back and might also now be occupied without fear. The owner of Snow View and Brae House has set a good example which might be followed with advantage by others.
- (8) *Brae Side*.—Should be dismantled, its site being quite unsound, except a small space in the roar.
- (9) *St. Cloud*.—This house, though built on a good, sound site, was originally so very badly constructed that nothing but complete dismantling and rebuilding further back (as has been done at Snow View) can be recommended.
- (10) *Staff quarters of old Government House*.—This building has never been injured in any way; there are no signs of cracks in its walls, and, since the erection of strong revetment walls on the roads below it, may be said to be fit for habitation, the hillside behind the house being also fairly sound and well supported.
- (11) *The Towers*.—Although rebuilt in 1879, has continued to crack every year since, and here it may be remarked that apparently all houses situated near the head of the "Ravenswood" ravine seem liable to crack every year, which points to some continuous settlement or dragging of the ravine in this neighbourhood.
- (12) *Mr. Lawder's new house built on "Bramley site."*—
- (13) *Norfolk House*.—
- Both (12) and (13)
cracked all over
after the landslip of
September 1880 and
were dismantled.
- (14) *Ravenswood*.—The house is now in such a dangerous state that the Committee recommend that it should also be dismantled. The site, however, is not condemned.
- (15) *Baugh Cot*.—Also on the edge of "Ravenswood" ravine, does not seem to have been yet much affected, but its site can never be considered good, and many of the revetment walls below it require reconstructing.
- (16) *Braemar*.—Is in very good condition, but the Committee noticed that the revetment wall to the lawn tennis ground had bulged slightly, though this bulging had not increased since September 1880, and the wall need not therefore be rebuilt at present.
- (17) *Kumaun Lodge*.—
- (18) *Assembly Cottage*.—
- (19) *Dunedin*.—
- The Committee are of opinion that as long as the
drainage near them is kept under proper control they
may all be considered safe as residences, although
the hill immediately behind Kumaun Lodge requires some attention,
as it is very steep and the revetment walls protecting it are insufficient
and weak. The same remark applies in a less degree to Assembly
Cottage.
- (20) *Lake View*.—Has now become quite secure by the successful diversion of the ravine above it, which formerly discharged itself through the outhouses on this site.
- (21) *Dudley Grove*.—In this neighbourhood, which was badly built, has been dismantled.
- (22) *Edgehill*.—This house (which was never much injured) has shown no signs of disturbance during the past two years. Its outhouses were destroyed in September 1880, and the site of the main building, though apparently safe, is very confined, having ravines on each side of it, which leave little or no room for the rebuilding of the outhouses. The main road below would be improved by the completion of the breast walling on the upper side.

- (23) *Spring Hall (now called Phoenix Park)*.—The former house was pulled down and has been rebuilt on a smaller scale under a new name. It might again be occupied, but more revetment walls are required to the approach road, &c.

GENERAL REMARKS.

8. *Sher-ka-danda hill*.—The various private and public roads on this hill (as well as in other parts of the station) require the attention of the Municipal Committee, as many places require good strong breast walls of small height, and all the side drains should be rendered impervious to water, dry stone drains being, in the opinion of the Committee, in nearly all cases worse than useless.

9. The Municipal Committee should be called upon to complete the road leading up to St. Loo gorge above St. Loo House site by continuing the small retaining wall commenced on lower side of road. Attention should also be drawn to the drain on the inner side of the broad road leading from St. Loo gorge up to the Government House, as it is not at present watertight.

30. In conclusion, the Committee would remark that the general protection of the ravines and hillsides between the limits reported upon in 1880 seem to have been very efficiently carried out, and this portion of the station is now in all probability as safe or safer than it ever was.

J. G. FORBES.

J. S. BERESFORD.

O. GARSTIN.

F. H. ASHURST.

H. PETMAN.

F. E. G. MATHEWS.

19

Preliminary Report of Committee convened under G. O. No. C.1133B.R. of 17th March 1883, to enquire into the present condition of the Government House at Naini Tal and to suggest remedies for the prevention of future mischief.

THE Committee assembled at Naini Tal on Monday, the 9th of April 1883, and during that day and the following examined carefully the whole building, inside and out, together with the subsidiary buildings, drains, plateau on which the block of buildings is erected, and adjoining hill.

2. Mr. Simeon, the Sub-Divisional Officer of Naini Tal, who has been in charge of the building for the past fourteen months; Mr. Docherty, late Temporary Supervisor, Public Works Department, at present employed under Mr. Ashhurst, District Engineer, Kumaun, at Bhim Tal, who was one of the subordinates engaged in the construction of Government House; and Mr. Ryan, Sub-Engineer, who has just relieved Mr. Simeon of the charge of the sub-division, and who was also employed during part of the time that the building was being constructed as a subordinate upon the work, were present during the inquiries that took place on Tuesday, the 10th instant, and assisted the Committee with much valuable information.

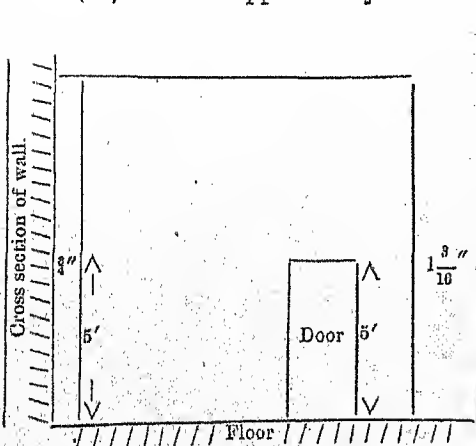
3. The three points upon which the Committee is directed to report are the following :—

- (i) The present condition of the house.
- (ii) The probable causes that have led to the present unsound condition of the house, and whether these causes are tending to further endanger the house.
- (iii) What steps they would recommend for the future.

4. (i) *The present condition of the building.*—A plan prepared by Mr. Simeon accompanies this report, and shows the position of the various cracks and the general condition of the building. As regards the defects to be reported on, they may be briefly summarized as follows :—

- (1) In the large arch between drawing room and ball room there are slight cracks on either side of the key and one in the key. Mr. Simeon states that when he took charge in February 1882 there was a considerable wedge-shaped cavity, about 8 inches, in the crown of the arch, extending from the soffit to the extrados, which is attributable to bad construction and pieces of slate and mortar having fallen out. No repairs have been executed to this since April 1882, when the cavity was filled and the arch properly repaired.
- (2) In the arch of the drawing room bow window, to the east, there is a crack of about $\frac{1}{2}$ inch in the key. This arch has had to be supported by a timber ornamental arch, and pillars, as Mr. Simeon states that a small segment dropped about an inch. This was pushed back, wedged with iron and lead, and supported as described.
- (3) Over the south door between the ball room and the dining room a large crack of an inch in width necessitated the dismantling of the arch, which, with a considerable portion of the wall, extending from the chauthat of the door to the cornice, was rebuilt in January last.
- (4) Over the north door in the same wall there is a slight crack, and in the wall to the north again of this door there is a slight crack over the site of a door, which has been walled up.
- (5) In the opposite wall of the dining room, next the butler's pantry, there is a considerable crack.

- (6) Between the main building and the staff quarters there is a longitudinal crack in the floor.
- (7) Over the west window of the billiard room there is a slight crack.
- (8) In the corridor all the arches are more or less cracked, the two flat arches on either side of the entrance hall more so than the segmental arches. At present these cracks are comparatively slight; they were much larger, but were repaired in 1881, and have not been since touched. These arches are tied by $1\frac{1}{2}$ inch rods.
- (9) The floor of the corridor from end to end has cracked considerably and has now been thoroughly repaired.
- (10) In the staff quarters there are considerable cracks in the east wall of the north room over each of the doors, and minor cracks in other parts shown on plan.
- (11) Besides these, there are numerous minor cracks over almost all openings in the lower storey of the building. These are detailed on the plan.
- (12) In the upper storey there is a corresponding crack to that in the lower in the corridor arches, which was filled and papered over in 1881, and which has since shown no sign of increase, as the paper on the arches is unbroken. There is also a separation between the upright woodwork at the end of the corridor and the wall, as shown in margin, but this cannot be depended on as evidence of separation in the building to the extent indicated, as much may be due to shrinkage of the wood.



5. (ii) *Probable causes of the present defective state of the building.*—The Committee is unanimously of opinion that the cracks, which are all longitudinal, were consequent upon the general disturbance of the hill during the cyclone of September 1880.

6. Mr. Ashhurst and Mr. Henslowe also are of opinion that unequal consistency in the subsoil under foundations has probably tended to increase the cracks, which tendency might perhaps have been prevented had a broader and thicker beam of concrete been given under each of the walls than it is understood has been provided.

Mr. Beresford does not entirely agree with this opinion, but considers that had

NOTE.—Mr. Docherty states that in the foundations soft patches of disintegrated shale alternating with hard rocky ground were met with, and that no special steps were taken with reference to the foundations on these patches.

NOTE.—Mr. Docherty states that although no concrete is shown in the plans, 6 inches were put in under the foundations.

NOTE.—Pressure on foundations= $1\frac{1}{2}$ tons per square foot.

The above notes are by Mr. Henslowe and are independent of the report.

no abnormal disturbance taken place, the foundations would have been found to be sufficient, provided they had been constructed as designed; but the Committee is unanimous in considering that in the absence of any violent and abnormal disturbance, such as a considerable slip in the vicinity of the building, no material extension of the damage is to be apprehended.

7. (iii) *What steps the Committee would recommend for the future.*—The only steps that the Committee recommend for the future preservation of the building are—

- (a) very careful maintenance of the approach roads, with their breast walls and drains;

(b) careful daily examination during the rainy season of the surface drainage of the whole platform or site, to ensure that little or no water enters the body of the hill, but that the whole of the storm water passes into and through the main drains and meets with no obstruction in its passage to the exits on the north side of the hill;

(c) that the section of the existing main drains should be improved by reducing the radius of the invert to 6 inches, as shown in sketch in margin;

(d) that all seriously cracked arches be rebuilt entirely with the best material.

8. *General remarks.*—The Committee is surprised to find that in spite of the warnings given in previous reports regarding the safety of Sher-ka-Danda hill a new approach road is in progress immediately beneath the south-west end of Government House, and it is strongly of opinion that this should be either stopped at once and the hillside be restored as far as possible to its original condition, or that the work should be immediately completed before the coming rains with very strong pakka masonry breast walls and side drains to carry off the water to the nearest ravines.

9. Some arrangements should at once be made for accurately gauging the more important cracks in walls and arches at certain periods to ascertain with better certainty than now is possible whether they really do increase or not, as, owing to the great variations of temperature in Naini Tal, it is impossible to say whether the re-opening of the cracks is not in a measure due to alternate contraction and expansion of the wall paper, woodwork, &c.

10. The Committee tested several of the walls and found that none were materially out of plumb; where slight deviations do exist, they are probably merely due to inequality in the masonry or plaster.

11. Mr. Docherty during the investigation informed the Committee of the existence of a large fissure in the plateau, which he stated commenced at an oak tree opposite the west end of the corridor and extended eastwards in the line of the latter through the building, passing under the conservatory towards a large rhododendron tree on the edge of the plateau. The cracks in the corridor follow the direction of this fissure.

12. The rough plan submitted with this report, which was prepared three weeks ago by Mr. Simeon to illustrate the position of the cracks, agrees very closely with a plan prepared by the late Executive Engineer of the Kumaun Division to accompany a note by Captain Yorke on the state of Government House in 1880 immediately after the great landslide.

F. B. HENSLOWE.

J. S. BERESFORD.

F. H. ASHHURST.

NAINI TAL: }

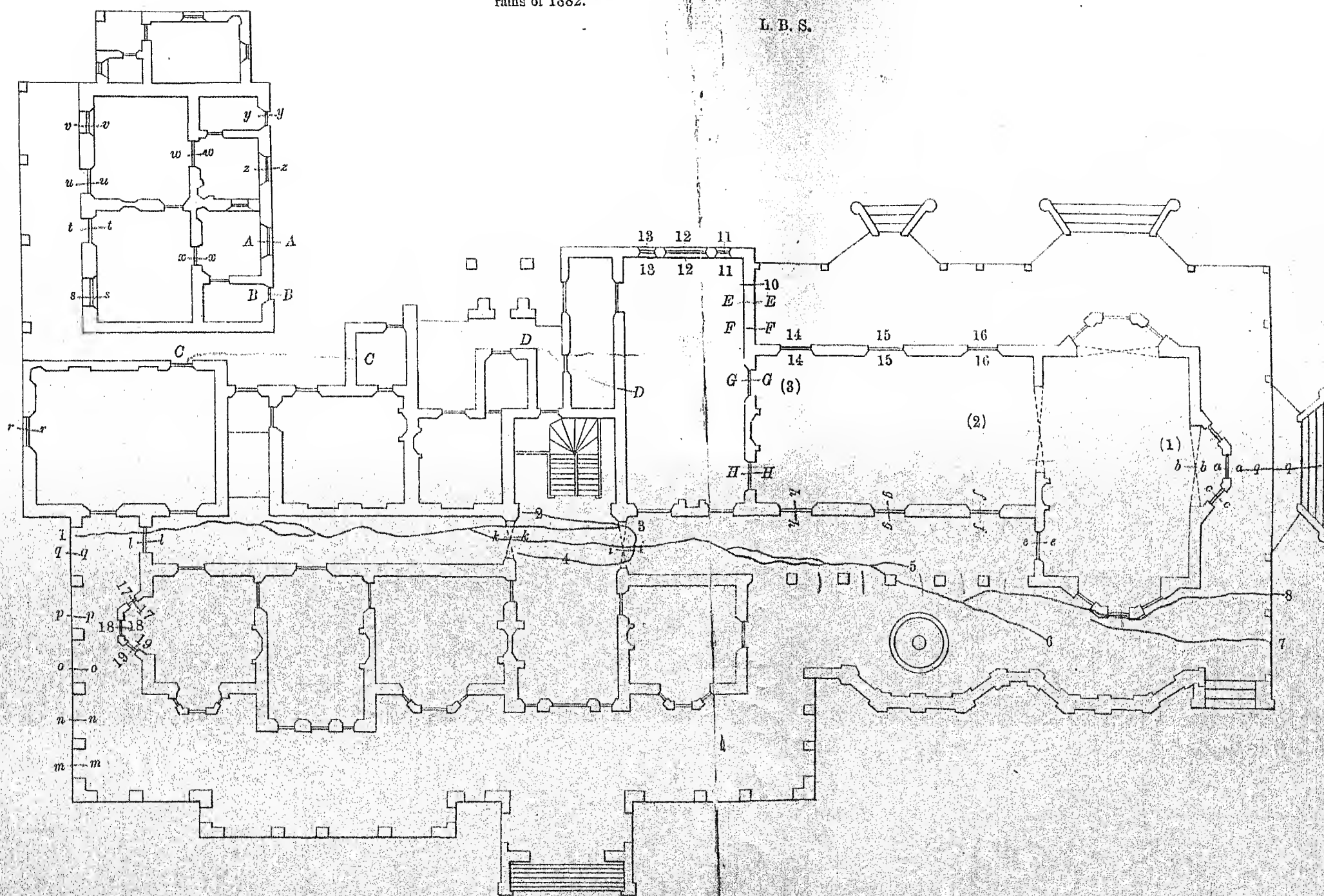
The 11th April 1883. }

Plan of GOVERNMENT HOUSE, NAINI TAL.

Scale—20 Feet to 1 Inch.

The blue lines show the cracks that have been re-repaired
in 1883.
The red lines show those that have not been touched since the
rains of 1882.

L. B. S.



L. B. SIMEON,
Assistant Engineer.
21st March, 1883.

OFFICE MEMO.

No. 3633 B.R., dated Naini Tal, the 14th September 1889.

THE points for consideration on which this Government requires advice are the following :—

* * * * *

- (6) the subsidence that seems to be going on slowly along the Government House ridge.

Memorandum by MR. R. D. OLDHAM, Deputy Superintendent, Geological Survey of India, on the questions submitted to him for opinion in Office Memorandum No. 3633 B.R., dated 14th September 1889.

ON Saturday, the 14th September, an office memorandum of the Public Works Department was submitted to me, stating the points on which my opinion and advice were required. I have since then carefully examined all the questions submitted, having received great assistance from Mr. F. B. Henslowe, Executive Engineer, and have, so far as the geological aspects are concerned, availed myself of the local knowledge of Mr. C. S. Middlemiss of the Geological Survey of India, after consultation, with whom the following memorandum has been drawn up. Seven points in all were submitted to me for opinion, which I propose to treat seriatim in the order adopted in the office memorandum No. 3633 B.R.

* * * * *

VI.—The subsidence that seems to be going on slowly along the Government House ridge.

This is no doubt a serious matter ; I can recollect that my attention was called to, and opinion asked on, this subject in 1880, since which date I find there has been a distinct further settlement of the hillside, the cause and nature of which is obscure. From the facts, that there is a distinct line along one side of which subsidence takes place, that a considerable part of the subsiding portion is rock and not soil-cap, and that the subsidence happens not during, but about a month after the cessation of the rains, I conclude that the movement takes place along some fault or fissure which runs at a considerable depth through the solid rock. There can be no doubt that this is a serious matter, and will ultimately be a source of danger ; but no immediate apprehension need be felt, which is fortunate as, owing to the enormous mass which is moving, and the obscurity of the cause to which its movement is due, I can see no prospect of dealing with it successfully.

* * * * *

NAINI TAL: } R. D. OLDHAM,
The 21st September 1889. } Deputy Superintendent, Geological Survey of India.

No. C.4061 B.R. of 1889.

RESOLUTION.

PUBLIC WORKS DEPARTMENT, BUILDINGS AND ROADS BRANCH.

Dated Naini Tal, the 25th October 1889.

READ—

* * * * *

IV.—Report, dated 21st September 1889, by Mr. R. D. Oldham, Deputy Superintendent, Geological Survey of India.

* * * * *

* * * * *

12. The subsidence of the Government House ridge, treated of under head VI of the report, cannot be regarded as otherwise than serious, whether on account of the obscurity of the cause, the apparent

impossibility of controlling it, or the value of the Government property in question. The Lieutenant-Governor observes that in Mr. Oldham's opinion no immediate apprehension need be felt. All that can presently be done is to endeavour to ascertain the extent of the subsidence since it was first noticed in 1880, and to devise means for accurately measuring and recording the movement, in order to foretell, if possible, the prospects of its continuance; to suggest the precautions, if any, that should be taken; and to prevent any further development being overlooked. The subject will be further considered in the Public Works Department, and orders issued accordingly.

ORDERED—

(e) that with reference to paragraph 12, the necessary action be at once initiated in the Public Works Department.

No. 3564B.R., dated 19th November 1889.

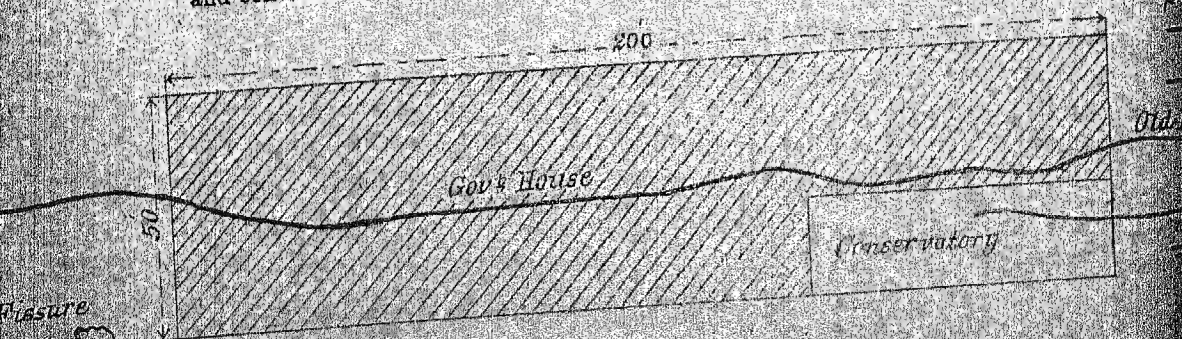
From—COLONEL J. P. STEEL, R.E., *Offg. Chief Engineer, N.-W. P. and Oudh,*
To—The Superintending Engineer, 2nd Circle, Provincial Works.

I have the honor to request that you will be good enough to issue instructions for the further investigation and early report of any measures that may now be considered necessary with reference to paragraph of Public Works Department Resolution No. C.4061B.R., dated 25th October 1889, also with reference to paragraph 12 of that Resolution, regarding the subsidence of the Government House ridge, treated under head VI of Mr. Oldham's report.

Inspection Report by the Superintending Engineer, 2nd Circle, Provincial Works, Naini Tal Sub-Division, Kumaun Division, dated 21st February 1890.

GOVERNMENT HOUSE.

IN re-roofing the conservatory, the pillars that had got out of plumb, and gave rise to suspicions about the failure of the foundations, have been set up straight. Two small slate slabs have been let in, at ground level, on either side of the passage, and a steel bar has been made to fit accurately between them. This bar will be kept on the spot, and any subsidence of the outer wall can be, by this means, easily detected. I do not propose to enter into the question of the cracks but in opening up the drains on the east and west of the house, certain cracks and fissures were noticed, of which I subjoin a sketch. They are not, I believe, any new thing, but are a part of the natural composition of the hill showing movement of expansion and contraction only under atmospheric changes.



The thin red lines show cracks, and the thick irregular lines fissures in the rock, two or three inches wide at the top.

LUCKNOW : } J. W. ALEXANDER,
The 24th February 1890. } *Superintending Engineer, 2nd Circle, Provincial Works.*

No. 824C., dated Lucknow, 27th February 1890.

From—J. W. ALEXANDER, ESQ, *Superintending Engineer, 2nd Circle,*
Provincial Works,

To—The Chief Engineer to Government, N.-W. Provinces and Oudh, P. W. Dept.

WITH reference to your No. 3564B.R., dated 19th November 1889, calling for further investigation and report on the condition of Government House at Naini Tal, I have the honor to submit the accompanying copy of a report* by the Executive Engineer on the subject.

* No. 3258C., dated 17th December 1889.

* * * * *

3. With regard to Government House, I believe that the cracks and fissures observed there are an inherent part of the composition of the hill. They were there before the house was built, and it is quite impossible, I think, to devise any measures of remedy. I do not think that there are any signs of the hill subsiding, nor, if there were, do I see how anything could be done to arrest the motion of the whole hillside. To my Inspection Report, which I am now submitting, I attach a sketch showing the cracks and fissures, and I express my opinion there that the only movements that take place are due to expansion and contraction under atmospheric changes. These, so far as we know, are not likely to be great enough to affect the stability of the building.

4. I have delayed submitting this report until I had an opportunity of again carefully examining the whole place.

No. 3258C., dated Naini Tal, 17th December 1889.

From—J. B. HENSLOWE, ESQ., *Executive Engineer, Kumaun Division,*

To—*Superintending Engineer, 2nd Circle, Provincial Works.*

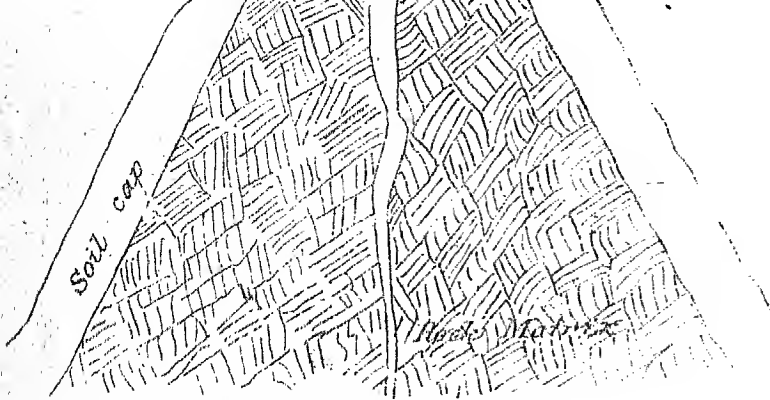
IN compliance with the instructions conveyed in your No. 4282 of the 20th ultimo, I have the honor to submit the following remarks upon the points referred to.

* * * * *

With reference to paragraph 12 of Resolution No. 4061 of 25th October 1889, I would remark that the subject is a serious and formidable one, and one for which precautionary measures beyond what has already been done are most difficult to devise.

I have ordered that small slate squares shall be let into the conservatory pillar bases on each side of the crack or fissure in the hill upon which Government House is built, so that the subsidence or separation may be accurately measured periodically, and as the conservatory is being entirely renewed and the outer wooden posts or upright will be made truly plumb, their departure from the perpendicular should any occur, will also furnish information as to the progress of the separation if such is still really going on; but to suggest any method of preventing half a mountain separating from the other half, I must frankly confess my inability, nor can I think that it is within the scope of human power or engineering skill and knowledge to arrest the movement which is apparently, though very slowly, going on.

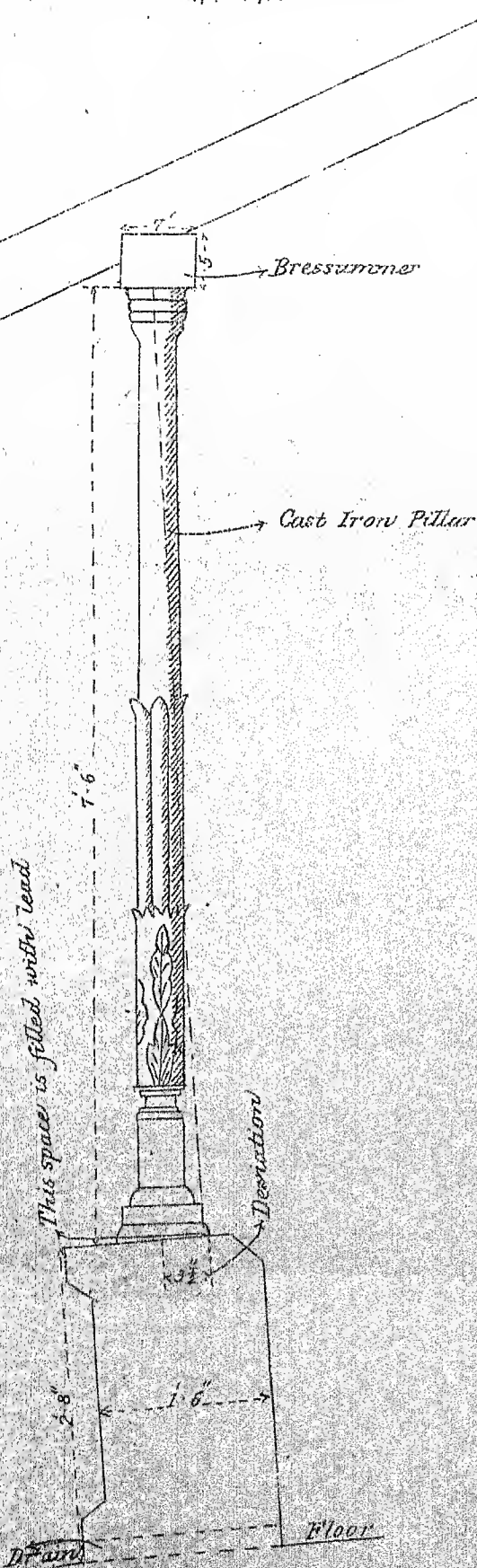
This question is one in which I have taken the deepest interest since 1881, when Colonel Brownlow informed me that he had been told that under Government House there was a fissure down which a stone if dropped could be heard falling for several seconds. I pointed out the indications of this crack or fissure to Mr. Oldham, and



showed him traces of it from Government House to and through "St. Cloud" and on to "Snow View," and he agreed with me that it is no movement of the soil-cap overlying the rocky matrix of the hill, but a distant separation through the axis of the hill itself as roughly indicated in the margin in an exaggerated manner.

The origin or cause of this separation, and to what extent it has already gone within the hill, it is impossible to ascertain. The surface indications during the last two years show a movement of about one-eighth to a quarter of an inch only. Judging from the separation in the tiled flooring of the corridor and conservatory, and gauged by the deviation of the outer pillars of the conservatory from the vertical, it would appear that since the erection of the house in 1880 the forward movement had not exceeded three inches to $3\frac{1}{2}$ inches as sketched in the margin.

I do not think that Mr. Oldham's inference regarding the period at which the apparent subsidence takes place is correct, although his conclusion that the movement takes place along "some fault or fissure which



runs at a considerable depth through the solid rock" most probably is. In my opinion the opening of the cracks a month or so after the rain ceases has no connection with the "movement" in the hill, but is due merely to the shrinkage of the materials as the temperature rises under the warm sun of September and October, and is an incident of no significance. I am also inclined to think that at present there is little, if any, movement going on: the fissure is a very large one, and extends to a great depth into the mountain; it has never been filled in to the bottom, and I believe that the periodical opening out of cracks in the corridor conservatory, garden, and in the adjacent compounds is due to the shrinkage and breaking up of the materials with which the upper portion of the chasm has been stuffed and their falling down in small particles.

I have had a portion of the tiled floor in the conservatory taken up when a slight new crack appeared, and this has disclosed a fissure four inches to six inches in width immediately beneath the tile down which a stick four or five feet long can be thrust: this is no new opening, or arches and floor would have shown cracks of the same width: it simply serves, I think, to bear out my theory.

No. C.1835B.R., dated Naini Tal, the 15th July 1890.

*From—Under-Secretary to Government, N.-W. P. and Oudh, P. W. Dept.,
Buildings and Roads Branch,*

To—Superintending Engineer, 2nd Circle, Provincial Works.

I AM directed to acknowledge the receipt of your report of inspection of the Naini Tal Sub-Division, dated 21st February 1890, and your No. 824C., dated 27th idem, regarding the condition of the Government House at Naini Tal, and in reply to request that a report may be submitted at the close of each rainy season on the State of the, also on the Government House at Naini Tal, and the hill on which it stands.

2. The Executive Engineer of Kumaun and the District Engineer of the Tarai should take suitable opportunities to keep themselves well informed of the state of these hills from time to time.

3. I am to say that a special book should be maintained from records of observations and notes made and written up at the end of each season, giving a brief account of the results of the year as to cracks, slips, changes, dangerous points, boulders, &c., which in time would form an instructive book of reference to future Engineers holding charge of Naini Tal.

25

No. 12701. of 1895.
GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
IRRIGATION BRANCH.

DATED NAINI TAL, THE 1ST APRIL 1895.

FROM

THE SECY. TO GOVT., N.-W. P. AND OUDH,
P. W. DEPT., IRRIGATION BRANCH,

TO

THE SECY. TO GOVT., N.-W. P. AND OUDH,
P. W. DEPT., BUILDINGS AND ROADS BRANCH.

SIR,

I HAVE the honor to submit, for the information of His Honor the Lieutenant-Governor, the report of the Committee on the cracks at the Government House, Naini Tal.

2. I wish to remark that I have never made any examination of the building, except on one occasion, viz., 18th October 1894, and that although I hold without reservation the opinions expressed in this report, I would be glad if the matter were considered by a larger Committee before any action is taken.

I have the honor to be,

SIR,

Your most obedient servant,

J. GODFREY,

For Secretary.

Report of the Committee appointed by His Honor the Lieutenant-Governor and Chief Commissioner, under Minute dated 3rd October 1894, to examine and report on the stability or otherwise of the site of Government House, Naini Tal.

1. Under date the 3rd October 1894 His Honor the Lieutenant-Governor wrote as follows regarding the marked increase in the size and extent of the cracks in Government House, Naini Tal:—

“SECRETARY, PUBLIC WORKS DEPARTMENT—

“I think the crack which is the outward sign of the subsidence of the ground underneath Government House is enlarging so much that it is necessary to examine the matter most carefully with a view to determine whether it is safe to remain on this site.

“Mr. Oldham's note of 14th September 1889 dealt briefly with this subsidence. His opinion was that it was a serious matter and would ultimately be a source of danger, but that there was no immediate apprehension then.

“Mr. Oldham said there had been a distinct further settlement in 1889 since he examined the site and gave an opinion on it in 1880. During the six years that have since elapsed the subsidence has continued, and if the cracks which have been filled up with plaster are measured, I think the movement as indicated at the top will be found to have amounted to from 4 to 6 inches. The subsidence during the few last weeks has been marked.

“I wish a Committee appointed to examine the matter and say whether the limit has been reached beyond which it would be foolish to remain.

“Colonel Corbett, R.E., Mr. Holme, and Lieutenant-Colonel R. R. Pulford, R.E., Officiating Chief Engineer, Buildings and Roads Branch, may form the Committee.”

2. In compliance with these instructions the Naini Tal Government House and site were carefully inspected on the 18th October 1894 by Lieutenant-Colonel F. V. Corbett, R.E., Chief Engineer, Irrigation Branch, and Lieutenant-Colonel R. R. Pulford, R.E., Officiating Chief Engineer, Buildings and Roads Branch.

The third officer nominated by His Honor the Lieutenant-Governor to form one of the Committee, *viz.*, Mr. C. H. Holme, Executive Engineer, was absent on leave and was unable to attend.

3. The inspection disclosed a very unsatisfactory state of affairs and one calculated to cause grave anxiety as to the stability and safety of the building. The Committee, after inspecting the cracks and places where the principal subsidence appeared to be in progress, *viz.*, in the conservatory and at the billiard room end of the building, decided to defer any definite expression of opinion as to the safety of the building pending the preparation by the District Engineer of Naini Tal of a detailed report and plan showing the exact location and extent of the cracks and their history, especially in regard to the rate at which they appear to be gradually increasing in size.

4. The report and map in question were submitted by the Divisional Engineer under date 13th February 1895, and contained a very full account of the cracks and settlements which now exist in the Naini Tal Government House, together with important measurements and observations made up to the 10th February 1895.

5. In the meantime the ground near the verandah at the billiard room end of the building having been opened out, an extensive series of cracks and fissures in the rock was disclosed immediately below the soil cap, which is there about 3½

feet deep and composed of shattered shale. The fissures in the rock were some 9 inches wide and of considerable depth. These vertical fissures are probably reproduced below the main corridor inside the building, along which a very marked crack seems to have been in existence ever since the house was built. It appears, however, to have first shown itself after the landslide of 1880. Colonel Pulford made a full inspection of the rock fissures on the 28th January 1895. He also again carefully inspected the entire site platform of the Government House enclosure.

Finally, on the 16th February 1895, he made a careful and detailed inspection of the entire Sher-ka-Danda hillside.

6. The Committee was now in a position to deal finally with the questions regarding the safety of the Government House at Naini Tal on which His Honor the late Lieutenant-Governor had asked for an opinion.

On the 12th March 1895 the Committee met at Agra for the consideration of the facts set forth in the District Engineer's report taken in connection with the information obtained by Colonel Pulford at his recent inspection of the Government House site and the Sher-ka-Danda hillside.

7. The accompanying is a copy of the District Engineer's report. It confirms very strongly the observations made by the Committee when they visited and inspected the building in October 1894.

8. The levels taken show that the front portion of the plinth of the building, *viz.*, that to the front of the longitudinal crack which runs along the corridor and connects the series of cracks in the conservatory with those near the billiard room, has settled down from 7 inches to 10 inches. That this settlement has apparently been accompanied by an outward movement of separation is proved by the steadily increasing widening which careful measurements show has taken place each year between the main wall of the drawing room and the outer wall of the conservatory.

9. This seems to indicate a steady widening of the longitudinal vertical fissure; and a grave feature in the case is that the rate of widening has shown a marked increase during the rains of 1894 as compared with previous years.

From the year 1890 the annual increments shown by the measurements taken in the conservatory have been—

							<i>Inch.</i>
1890	...	...	...	...	...	...	$\frac{1}{16}$
1891	...	...	...	...	...	...	$\frac{9}{16}$
1892	...	...	...	...	...	...	$\frac{4}{16}$
1893	...	...	...	...	...	...	$\frac{4}{16}$
1894	...	...	...	...	...	...	$\frac{16}{16}$
							1

The total increase amounted to 2 $\frac{1}{2}$ inches on 16th January 1895.

10. That some movement is taking place in the plateau on which the Government House is built is beyond doubt. Writing in September 1889, Mr. Oldham, Deputy Superintendent of the Geological Survey of India, stated as follows:—

“This is no doubt a serious matter. I can recollect that my attention was called to, and opinion asked on, this subject in 1880, since which date I find there has been a distinct further settlement of the hillside, the cause and nature of which is obscure. From the facts that there is a distinct line along one side of which subsidence takes place, that a considerable part of the subsiding portion is rock and not soil cap, and that the subsidence happens not during but about a month after the cessation of the rains, I conclude that the movement takes place along some fault or fissure which runs at a considerable depth through the soil rock.

"There can be no doubt that this is a serious matter and will ultimately be a source of danger, but no immediate apprehension need be felt, which is fortunate, as, owing to the enormous mass which is moving and the obscurity of the cause to which its movement is due, I can see no prospect of dealing with it successfully."

11. Mr. Oldham, it is true, states here that no immediate apprehension need be felt; but that view applied to a time when the walls and floors of Government House had not commenced to show the well defined cracks which now exist, and in any case applied more to the geological future of the hill than to the more immediate conditions of the houses built on the top of it.

12. It is impossible to admit that the present state of the Government House is satisfactory, or that from the point of view of entire safety it is suitable for occupation by the Head of the Local Government during a season of excessive rainfall.

Without going so far as to say that there is probability of a disaster, the Committee are constrained to express their opinion that in view of the constant settling and cracking which has been seen to happen every rainy season, and of the marked increase in the width and extent of the cracks during the past season of 1894, a serious accident may, at any time after the beginning of the rainy season, be brought about by some sudden structural failure within the building itself.

On this view of the question and with special reference to the point on which the opinion of the Committee was specially called for, *viz.*, "whether the limit has been reached beyond which it would be foolish to remain," they consider that it would be advisable for the house to be vacated during the rains of 1895.

13. The Committee draw attention to the fact that a system of underground surface-water drains exists on the Government House plateau, which in its present state is calculated to have a prejudicial effect on the stability of the site. These drains have been cracked and injured by the subsidence of the various portions of the site over which they extend, with the result that the water drained into them is forced to empty itself by percolation into the body of the hill. This is the precise state of affairs which the Committee of 1880 was most anxious should by all possible means be avoided.

These drains should be entirely overhauled and should be made entirely open for the future.

F. V. CORBETT, LIEUT.-COL., R.E.
R. R. PULFORD, LIEUT.-COL., R.E.

The 27th March 1895.

Extract from the report of the District Engineer, Naini Tal, for the year 1894, dated the 10th February 1895.

GOVERNMENT HOUSE.

CAREFUL observations were made of the movements of the cracks at Government House. It would appear that the cracks first showed themselves in the walls of Government House in 1880, the great landslip year, shortly after the completion of the building, and fissures were already observed in the rocks at the time when the foundations of the building were put in. Originally the cracks were but insignificant, but they widened out year by year, and after the heavy rain in 1890, when the Ballia Bridge near the Brewery was carried away, the Chief Engineer ordered a record of the cracks to be kept. A plan of them was accordingly made, and detailed descriptions of them recorded on pages 9 to 13 of this book. An inspection of these records shows that the cracks in the year under review, 1894, are substantially the same as were recorded in 1890, but there has been considerable movement in the larger longitudinal cracks during the last four years.

The District Engineer has had a new plan prepared, accompanying this report, which shows the exact position of all the cracks in the walls of Government House at the beginning of 1895. The most important crack, and which does most damage to the building, is the long longitudinal fissure along the conservatory and corridors. To intercept this one and some smaller parallel ones shown on the plan the Officiating Chief Engineer ordered two trenches to be dug parallel to the building on the east and west sides. This was done, and some levels were also taken, which show that the building has sunk in front some 6 to 8 inches right along.

The trench on the east side of the building near the drawing room exposed nothing but loose clay slate to a depth of about 5 feet, and as fast as the fissures were dug out they filled up with rubbish, and it was impossible to ascertain their width in the soil. The foundation masonry of the verandah wall is carried down to a depth of 2 feet below ground level, and the width of the long fissures crossing the wall between the pillars 1 and 2 measured $\frac{5}{8}$ inch in the masonry; similarly the fissures between pillars 2 and 3 measured $1\frac{1}{2}$ inches width in the foundation masonry of verandah wall.

The direction of fissures was vertically down (more or less) and not along the dip of the strata, which are inclined in a south-west direction at an angle varying between 30° and 40° .

On the west side, near the billiard room, the trench touched solid limestone rock a couple of feet below the surface, and in the rock were wide gaping fissures as much as 9 inches wide in places and of unknown depth; a stone could be heard to drop down and touch the sides for some seconds. The fissure was followed up from the billiard room window along the red line on plan where the widths of fissure are shown in red numbers. The width of the crack in the foundation masonry below the billiard room window is 3 inches.

Three lines of levels were run on the 9th December 1894, giving cross sections through the centre and the east and west verandahs and showing the amount of settlement that has taken place in front.

The levels were as follows:—

Levels along east verandah.

			R. L.
Plinth level, north wall of east verandah	...	...	100.00
" centre " "	...	...	99.87
" south wall " "	...	...	99.33
Total fall in verandah from north to south			<u>.67 feet</u>
			<u>=8.04 inches.</u>

Levels along west verandah and billiard room.

				R. L.
Against north wall of billiard room ...	...	...	...	100.22
Outside doors, south wall of billiard room	...	...	...	100.06
Plinth, south opening of verandah ...	...	...	...	99.65
				<hr/>
		Total slope	...	.57
				=6.84 inches.

Levels along hall and portico.

Against north jamb of arch leading to conservatory	...	...	100.08
" south " " " "	...	...	99.95
Plinth of portico	...	...	69.29
Total slope	...	...	.79
			= 8 1/2 inches.

These levels would seem to show that the settlement of the building in front varies from about 7 to 10 inches.

Numerous measurements were taken at the marked spot in the conservatory between the outer wall and the drawing room wall, which give the following measurements between the end of iron rod and wall :—

In July 1890, the rod just equalled the length of opening, *vide* page 17.

1st August 1890, extra length of opening	...	...	$\frac{1}{16}$	"	17.
24th June 1891 ...	...	...	$\frac{1}{8}$	"	19.
7th June 1892 ...	...	...	$\frac{7}{8}$	"	39.
August 1893 ...	...	...	1	"	59.
Winter, 1893-94	...	...	$1\frac{1}{8}$	"	
June 1894 ...	...	...	$1\frac{1}{4}$	"	
8th September 1894	...	...	$1\frac{3}{4}$	"	
8th October 1894	...	...	$1\frac{15}{16}$	"	
18th October 1894	...	...	$1\frac{31}{32}$	"	
15th November 1894	...	...	$2\frac{1}{16}$	"	
6th December 1894	...	...	$2\frac{1}{2}$	"	
16th January 1895	...	...	$2\frac{1}{2}$	"	

These measurements show that during the course of the last year, 1894, the width of the conservatory at the place measured has increased by a full inch, which is very great and can only be accounted for by the unusually heavy rain, and the subsequent shrinking and cracking of the soil.

Some more levels were taken, 5th December 1894, with the three feet long billiard room spirit level, giving the following results:—

- (1) At arch leading into conservatory, at end of double storeyed portion of building, the walls south of crack are 1 inch below those north of crack.
- (2) At above point where crack passes through new encaustic tiling laid in April 1894, the south edge of crack is $\frac{1}{2}$ inch below north edge, giving the amount of settlement during year up to 15th December 1894. In the hall the settlement is only $\frac{1}{4}$ inch in new floor at crack.
- (3) The main longitudinal crack has widened during the year $\frac{1}{4}$ inch on east side and somewhat less (about $\frac{1}{8}$ inch) on west side, as shown by actual measurement where the crack was filled up with plaster in March 1894, and shows a crack $\frac{1}{4}$ inch in December 1894.
- (4) South wall of dining room has separated from side walls, the wood work of roof showing a crack of more than 1 inch wide, and at south-east corner the dado shows a crack $\frac{1}{2}$ inch wide.

- (5) At the west end of corridor the sill of door leading into verandah is $1\frac{1}{2}$ inches lower on south side than on north side in the three feet length of spirit level.
- (6) West window in billiard room was similarly $\frac{1}{2}$ inch lower on south side.
- (7) Door of No. 15, Staff Quarters, leading from corridor—sill slopes $\frac{3}{4}$ inch in 3 feet.
- (8) No. 19, Staff Quarters—door sill slopes 1 inch in three feet.
- (9) Window in same room—sill slopes $\frac{3}{4}$ inch, chaukhat $\frac{1}{2}$ inch.
- (10) Outer door to No. 20 bath room—plinth slopes 1 inch in 3 feet, measurement taken on concrete outside door.
- (11) Window in No. 15, Staff Quarters—sill slopes $\frac{3}{4}$ inch in 3 feet.
- (12) At west end of corridor, at corner of stairs, floor slopes $1\frac{1}{4}$ inches in 7 feet.
- (13) Floor of corridor, measured west of door to Aide-de-Camp's (No. 3) room, slopes $1\frac{3}{4}$ inches in 7 feet.
- (14) Slope of corridor under arch in east wall of hall—1 inch in 7 feet.
- (15) Slope of corridor under arch leading to conservatory— $1\frac{1}{2}$ inches in 7 feet.
- (16) Sill of south door leading from dining to ball room slopes $\frac{2}{3}$ inch in 3 feet.
- (17) Slope of conservatory at the place where the measurements are taken near drawing room is $6\frac{3}{16}$ inches.
- (18) Slope of conservatory in front of His Honor's office, near down pipe, $1\frac{1}{2}$ inches.

The above measurements are to be kept on record, so as to be able to tell if any sudden settlements take place. A special measurement book will be kept up in which periodical measurements will be recorded.

As already stated, the main longitudinal crack opened out again all through the new encaustic tiling floor laid in April 1894. A large piece of plaster fell down from the arch between the corridor and conservatory, and this has been now boxed in with woodwork to prevent a similar accident happening again. The arch was first carefully wedged up with pieces of flat iron; similarly the large arch between the drawing and ball rooms has been wedged up, as the fissure in the crown opened out during the year. The arch over the door leading out at the west side of corridor had also to be rebuilt, and the door chaukhat was straightened, the settlement having twisted it all out of shape. In the upper storey the arch and chaukhat of the window in His Honor's dressing room, which is above the arch leading into the conservatory, had to be similarly treated, as the chaukhat was twisted out of shape and the large panes of glass broken.

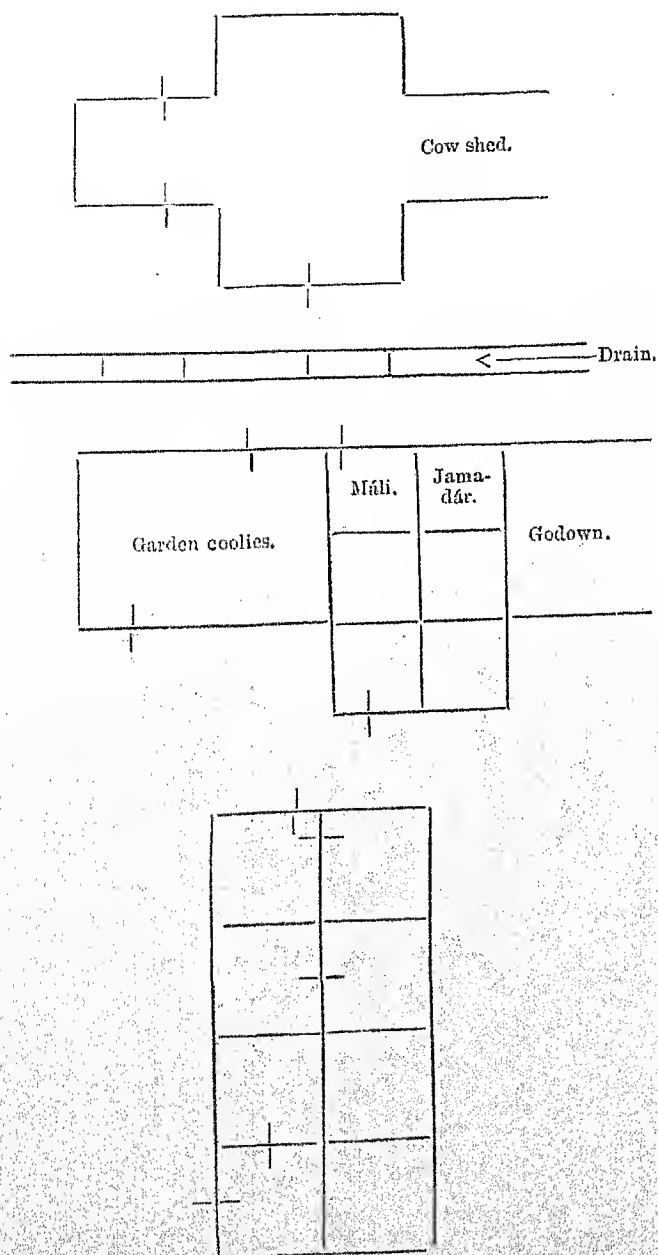
The crack on the upper badminton court near St. Loe Gorge has opened out again, and it is proposed to slope it off to the original angle. Some cracks have also shown on the roads below Government House, and would seem to indicate a movement in the surface soil.

The St. Loe outhouses which are above "Ravenswood" have a great number of cracks in them, which have opened out more during 1894. The sketch plan below indicates their position.

F. O. OERTEL,
District Engineer.

The 13th February 1895.

Sketch plan of St. Loe outhouses showing cracks in January 1895.



The 13th February 1895.

F. O. OERTEL,
District Engineer.

Telegram, dated the 29th March 1895.

<i>From—Lucknow.</i>	|	<i>To—Calcutta.</i>
<i>From—Works, N.-W. Provinces.</i>	|	<i>To—Works.</i>

SERVICES experienced officer Geological Department urgently required to advise regarding stability Government House hill, Naini Tal. Lieutenant-Governor will be much obliged by early deputation suitable officer.

Telegram, dated the 1st April 1895.

<i>From—Lucknow.</i>	|	<i>To—Simla.</i>
<i>From—Works, N.-W. Provinces.</i>	|	<i>To—Works.</i>

TELEGRAM 29th March and letter this date. Lieutenant-Governor desires services Mr. Beresford, Chief Engineer, to act on Committee to enquire into condition Government House, Naini Tal, and solicits early deputation, matter being urgent. Central Provinces Government agrees. Experienced officer, Geological Survey, also required for Committee, which should assemble very early.

Telegram, dated the 8th April 1895.

<i>From—Simla.</i>	|	<i>To—Naini Tal.</i>
<i>From—Works.</i>	|	<i>To—Works, N.-W. P.</i>

991G. Your telegrams 29th March and 1st April. Mr. Oldham, Geological Survey, ordered to proceed Naini Tal immediately. Deputation of Mr. Beresford can be arranged by North-Western Provinces and Oudh Government and Chief Commissioner, Central Provinces, under Articles 98 and 1137, Civil Service Regulations.

GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
BUILDINGS AND ROADS BRANCH.

DATED NAINI TAL, THE 1ST APRIL 1895.

FROM

THE SECY. TO GOVT., N.-W. P. AND OUDH,
P. W. DEPT., BUILDINGS AND ROADS BRANCH.

TO

THE SECRETARY TO THE GOVERNMENT OF INDIA,
PUBLIC WORKS DEPARTMENT.

SIR,

I AM directed to explain the circumstances under which a telegram, dated the 29th March, was despatched to the Government of India asking that the services of an experienced officer of the Geological Survey of India might be deputed for the purpose of examining the hill at Naini Tal on which Government House is built and reporting on its stability.

2. In 1880, the year of the great landslip at Naini Tal, various cracks were observed in the walls of Government House which had then only been recently completed, and, though insignificant at first, they widened out year by year, and have now reached dimensions which give cause for grave alarm. In 1889 Mr. R. D. Oldham, of the Geological Survey of India, recorded a brief note on the subsidence which was then apparent in the building. He stated that since his opinion was asked on the same subject in 1880 there had been a distinct further settlement of the hillside, the cause and nature of which he was unable to specify. During and after the rains of last season the cracks increased to a greater extent than in any previous year, and as they unquestionably are the result of movement of some kind, attributable either to defective design or faulty workmanship in the building (which have not been detected and may not exist), or more probably to the settlement or slipping of the hill itself and the opening out of the fissures on the top of the hill which were observed when the foundations of the building were being laid, His Honor the late Lieutenant-Governor ordered the matter to be referred to a Committee for consideration. The Committee consisted of Lieutenant-Colonel Corbett, R.E., Chief Engineer, Irrigation Branch, and Lieutenant-Colonel Pulford, R.E., (then) Officiating Chief Engineer, Buildings and Roads Branch, and the report has now been received. The Committee show

that a portion of the plinth of the building has settled down as much as from 7" to 10", and that the settlement has been accompanied by an outward movement of separation. This is proved by measurements which have been taken periodically of the distance between the main wall of the drawing room and the outer wall of the conservatory. From the year 1890 the annual increments shown by these measurements have been—

1890	...	...	...	...	$\frac{1}{16}$ "
1891	...	...	...	...	$\frac{9}{16}$ "
1892	...	...	...	...	$\frac{4}{16}$ "
1893	...	...	...	...	$\frac{4}{16}$ "
1894	...	...	...	...	1"

On the 15th January last the total increase amounted to $2\frac{1}{8}$ ". The Committee consider that it is impossible to admit that the present state of Government House is satisfactory, or that from the point of view of entire safety it is suitable for occupation by the Head of the Local Government during a season of excessive rainfall, and advise that the house should be vacated during the rains of 1895. In forwarding the report Colonel Corbett recommends that before action is taken on it, the matter should be enquired into by a larger Committee, and His Honor the Lieutenant-Governor concurring in this view, the telegram under reference was sent to the Government of India.

3. The question of the safety of Government House is one of grave importance, not only to Government, but also to the whole community of Naini Tal, and more especially to private owners of houses on the same hill, and demands the most careful consideration that it is possible to give to it. Bearing this in mind, His Honor the Lieutenant-Governor is of opinion that the matter should be enquired into by a Committee of not less than five members, and that it should assemble at a very early date. It is desirable that the Committee should include an experienced officer of the Geological Survey of India, who has given the study of the hills in and around Naini Tal special attention, and I am to ask that the Government of India will be pleased to appoint such an officer. Mr. Cadell would, I am to say, be glad if the services of Mr. J. S. Beresford, Chief Engineer, Central Provinces, could be made available to act on the Committee, as from his intimate acquaintance with the locality and the knowledge he has acquired from having already served on similar Committees at Naini Tal, he would be of the greatest use. The remaining members of the Committee would be appointed by His Honor the Lieutenant-Governor. The information which has already been collected will be of great help to the Committee in forming an opinion, and it is probable that the further information required will be got by making a careful examination of the hill. The Committee would probably therefore be able to dispose of the business before it in a very few days.

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4. I am to add, in conclusion, that it is of importance that the matter should be enquired into at a very early date, for, should the Committee condemn Government House, it will be necessary to make other arrangements for the accommodation of His Honor the Lieutenant-Governor for the season of 1896.

I have the honor to be,

SIR,

Your most obedient servant,

J. G. H. GLASS,

*Secy. to Govt., N.-W. P. and Oudh,
Public Works Department.*

Note by Secretary to Government, North-Western Provinces and Oudh, Public Works Department.

On the evening of the 28th March 1895 Colonel Corbett brought to me at Lucknow the report by himself and Colonel Pulford on Government House, Naini Tal, ordered by Sir Charles Crosthwaite on the 4th October 1894. On the following day I took it over to His Honor Mr. Cadell, and suggested that the larger Committee recommended by Colonel Corbett should assemble at an early date, and that Mr. Beresford, Chief Engineer, Central Provinces, who had previously served on committees connected with the question of the stability of the Naini Tal hills and has great local knowledge of Naini Tal, should be the President of it. I also recommended that the Committee should include amongst its members an experienced geologist who was acquainted with Naini Tal. His Honor agreed. India was wired to on the same date, asking for the services of an experienced geologist, and on the following day His Honor's approval was given to the letter to the Government of India which issued as No. 2432W.A., dated the 1st April. The report of Colonel Corbett's Committee was forwarded to me officially on the 1st April.

Dated the 10th June 1895.

J. G. H. GLASS.

[To be substituted for the G. O. of same No. and date].

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No. 2609W.A. OF 1895.

GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
BUILDINGS AND ROADS BRANCH.

DATED NAINI TAL, THE 22ND APRIL 1895.

HIS HONOR the Lieutenant-Governor is pleased to appoint a Committee to consider and report on the safety of Government House, Naini Tal, with the object of ascertaining if it is desirable that it should continue to be occupied as a residence. The Committee should in this connection examine the numerous cracks which have developed in Government House, enquire into their history, and endeavour to assign a cause for them. The attention of the Committee is invited to the report dated 27th March last on Government House, drawn up and submitted by Colonels Corbett and Pulford, R.E., a copy of which is forwarded herewith. The Committee will consist of the following gentlemen, and should assemble at a very early date:—

Mr. J. S. Beresford, Chief Engineer, Public Works Department	<i>President.</i>
Lieutenant-Colonel R. R. Pulford, R.E., Superintending Engineer	} <i>Members.</i>
Mr. C. Perrin, Superintending Engineer	...	...	...
„ R. D. Oldham, Geological Survey of India	...	...	...
„ J. R. C. Nicolls, Executive Engineer and Personal Assistant to Chief Engineer, Public Works Department, Buildings and Roads Branch	...	...	...
„ W. B. Gordon, Executive Engineer and Personal Assistant to Chief Engineer, Public Works Department, Irrigation Branch	...	...	...

Mr. F. O. Oertel, Executive Engineer, is appointed Secretary to the Committee in addition to his own duties as District Engineer, Naini Tal.

J. G. H. GLASS,

*Secy. to Govt., N.-W. P. and Oudh,
P. W. Dept., B. and R. Branch.*

35
NAINI TAL:
The 3rd June 1895.

To

THE SECY. TO GOVT., N.-W. P. AND OUDH,
P. W. DEPT., BUILDINGS AND ROADS BRANCH.

SIR,

I HAVE the honor to submit, for the information of His Honor the Lieutenant-Governor, the Report of the Committee convened under G. O. No. 2609, of the 22nd April 1895.

I have the honor to be,

SIR,

Your most obedient servant,

F. O. OERTEL,

Secretary to the Committee.

ENCLOSURES:

1. Report of the Committee, dated 11th May 1895.
2. Note on the Report by Mr. R. D. Oldham, dated 13th May 1895.
3. Memorandum by the President on Mr. Oldham's note of 13th May 1895.
4. Copy of Mr. Oldham's dissent, dated 24th May 1895.
5. Memorandum by the President on Mr. Oldham's dissent, dated 24th May 1895.
6. Appendices A, B, and C.
7. Four plans.

Report of the Committee convened under G. O. No. 2609, dated 22nd April 1895, to consider the safety of Government House, Naini Tal.*

—:O:—
COMMITTEE.

Mr. J. S. Beresford, Chief Engineer, Public Works Department	President.
Lieutenant-Colonel R. R. Pulford, R.E., Superintending Engineer	Members.
Mr. C. Perrin, Superintending Engineer ...	...	...	...	...
„ R. D. Oldham, Superintendent, Geological Survey of India...	...	...	...	...
„ J. R. C. Nicolls, Executive Engineer and Personal Assistant to Chief Engineer, Buildings and Roads Branch ...	...	...	...	...
„ W. B. Gordon, Executive Engineer and Personal Assistant to Chief Engineer, Irrigation Branch ...	...	...	...	...
„ F. O. Oertel, Executive Engineer	Secretary.

THE Committee first met at Government House on the 23rd April 1895, and, on this and many subsequent occasions, carefully examined the building and site, the cracks in the walls, the underground drains, and other objects of importance connected with the enquiry. Numerous measurements, plumbings, and levels were taken to ascertain accurately the present condition of the building. Mr. Docherty, who helped to supervise the construction of the building, and Captain Ryan, who was employed in levelling off the site, and who was afterwards in charge of the completed building, gave information as to the fissure that is said to have existed before the construction of the house. Mr. Gilbert, Assistant Engineer, who was in charge of the work during construction, has also given information regarding the first appearance of cracks on the 19th September 1880, the morning after the landslide.

2. The Committee frequently inspected the Government House hill, the cracks in the St. Loe grounds, and in houses adjacent to Government House. They also carefully investigated the fissure along the summit of the Sher-ka-danda hill, between the Alma and St. Loe gorges.

3. In the Government Order of 22nd April 1895 the attention of the Committee is invited to the report by Colonels Corbett and Pulford, dated 27th March 1895, on Government House. The Committee have fully considered this report, and are of opinion that the measurements across the crack at the one place in the conservatory, recorded since 1890, and the levels of the verandah plinth on the east side of the house as given in the District Engineer's report of 13th February 1895, although correct in themselves, cannot be regarded as a true measure of any movement which has taken place within the main building. The careful measurements which have now been made by the Committee indicate that the main building

* Extract from G. O. No. 2609 W.A., dated 22nd April 1895.

His Honor the Lieutenant-Governor is pleased to appoint a Committee to consider and report on the safety of Government House, Naini Tal, with the object of ascertaining if it is desirable that it should continue to be occupied as a residence. The Committee should in this connection examine the numerous cracks which have developed in Government House, enquire into their history, and endeavour to assign a cause for them. The attention of the Committee is invited to the report dated 27th March last on Government House, drawn up and submitted by Colonels Corbett and Pulford, R.E., a copy of which is forwarded herewith.

nowhere shows a lateral movement on a scale corresponding to the recorded measurement across the one longitudinal crack in the conservatory. The walls in the corridor west of the conservatory have not separated to an appreciable extent, although the south wall appears to have sunk by about 1½ inches. The front part of the building generally appears to have subsided vertically in the main building from two to four inches, on the assumption that the floors and plinths were originally built to the same level. The main walls are nowhere seriously out of the vertical, as may be seen from the appended statement of the result of plumbing at various points (*vide* Appendix A). The roof timbers are nowhere distorted, or drawn from their bearings. The levels given by the District Engineer of the verandah plinth on the west side of the building have been checked, and the amount of sinking found to be considerably less than stated. This is explained by an error in overlooking the original slope of verandah floor; the actual sinking is found to be 2½ inches instead of 6.84 inches given in the report. The various levels taken, reduced to a common datum, are shown on the accompanying ground plan No. 2, which also exhibits the position of the various cracks observed.

4. The Committee inspected the main underground drain on the east side, and opposite the south-east corner of the house where it had been opened for the purpose of examination, and found it in a very defective condition. There are several wide cracks across the drain between the man-holes B and D, which are 110 feet apart. There is a reverse fall of 9 inches in this distance, showing that, on the supposition that the drain was properly laid out, it has sunk bodily some 12 or 15 inches at B. Drainage from the roof of the house and a large proportion of the surrounding flat area must have run into the body of the hill through cracks between B and D, causing saturation of the ground where the marked subsidence and separation have taken place in the east verandah and conservatory. There are no cracks opposite to the conservatory in the portion of the drain which runs westwards from B. In the opinion of the Committee, these defects in the main drain have had a material and progressive effect in increasing the subsidence in the particular area noted.

5. The present Committee have read with interest the report, dated 11th April 1883, of the three Engineers* appointed under G. O. No. 1133B.R., dated 17th March 1883, to enquire into the condition of Government House, Naini Tal.

* Messrs. Henslowe, Beresford, and Ashhurst.

That Committee were directed to report on the following points:—

- (1) The condition of the house.
- (2) The probable causes that led to the unsound condition of the house, and whether those causes tended further to endanger the building.
- (3) What steps the Committee would recommend for the future.

6. These points were fully reported on. Under (1) were described in detail the various cracks in the building, which are shown on the accompanying plan No. 1 signed by Mr. Simeon, on 21st March 1883. The description might, without sensible error, be accepted as applicable to the cracks at the present time, except that since 1883 there appears to have been a vertical subsidence in the front part of the building, which has accentuated the cracks in the corridor; and that the longitudinal crack in the conservatory has largely developed since 1893. Several of the walls were tested in 1883, when it was found none were materially out of plumb.

7. Under head (2) the Committee of 1883 were unanimously of opinion that the cracks, which were all longitudinal, were consequent upon the general disturbance of the hill during the cyclone of September 1880. Messrs. Henslowe and Ashhurst were also of opinion that unequal consistency in the subsoil under foundations had probably tended to increase the cracks, which tendency might have been prevented had a broader and thicker layer of concrete been provided under each of the walls.

The Committee of 1883 were, however, unanimous in considering that, in the absence of any violent and abnormal disturbance, such as a considerable slip in the vicinity of the building, no material extension of the damage was to be apprehended.

8. Regarding point (3), *viz.*, what steps they would recommend for the future preservation of the building, the Committee of 1883 suggested the following :--

- (a) very careful maintenance of the approach roads, with their breast walls and drains ;
- (b) careful daily examination, during the rainy season, of the surface drainage of the whole platform or site, to ensure that little or no water enters the body of the hill, but that the whole of the storm water passes into, and through, the main drains and meets with no obstruction to its exit on the north side of the hill ;
- (c) that the existing main drains be improved as shown in diagram ;
- (d) that all cracked arches be rebuilt with the best materials.

9. It was noted by the Committee of 1883 that arrangements should be at once made for accurately gauging the more important cracks.

The Committee of 1883 commented on the construction of the new zigzag road below Government House, then in progress, which had been started in spite of all the warnings of the Committee of 1880.

Further, the Committee of 1883 in their report referred to the statement of Mr. Docherty regarding the existence, before the construction of the house, of a large fissure in the plateau, commencing at an oak tree on the west side of the building, and extending in a line with the corridor to a large rhododendron tree on the edge of the plateau.

10. The present Committee observe with surprise that no action appears to have been taken on the report of the Committee of 1883, or attention paid to the important recommendations contained in the report. Colonel Pulford, who was Under-Secretary in the Buildings and Roads Branch at the time, states he has no recollection of even having seen the report, and it was with some difficulty a manuscript copy was discovered in the Secretariat during the enquiry of the present Committee, for whose information it has been printed.

The report of 1883 was not brought to the notice of the Committee appointed in October last.

11. The history of the cracks in Government House is not very complete. The earliest recorded reference to the fissures said to have existed in the site before the house was built is contained in Executive Engineer, Kumaun Division, (Mr. Lawder's) No. 31B.A.C., dated 4th February 1879, to the address of the Superintending Engineer, 1st Circle, Provincial Works, in the following extract :—

“Notwithstanding the unavoidable exposure of the uncovered walls to the severe weather, I am happy to say they have suffered little from the test, and the masonry in them has proved excellent, as both yourself and the Chief Engineer have lately observed on your inspections. Nevertheless, from experience gained during these rains, it is most desirable that the whole site should be thoroughly well drained at once to the north side of the hill, over the strike of the clay shale beds. This formation dips at about 45°* to the south-west, and is more or less decomposed and traversed by ramifying fissures. The site, as excavated, has cut across the stratification, and the surface water (unless diverted to a part where it will be harmless) must penetrate the fissures and layers of shale, decomposing it as it flows through it, until it eventually

* The dip of slate cropping out of hill below the flag-staff as actually measured was found to be 84°.—J. S. B.

causes either a large landslip, or a settlement equally dangerous to the building. To prevent this, it will be necessary to construct good large drains of lime masonry through the site, which will take up all the roof and surface drainage, and discharge it over the scarp to the north."

The next reference to the subject is contained in the last paragraph but one of the report of the Committee of 1883. Mr. Docherty's evidence on this point is given in a statement appended to the present report. It will be seen, however, that Mr. Gilbert, who was in charge of the work from January 1879 to February 1882, states he never heard anything of the fissure during the three years he was on the work. The foundations had been laid and the superstructure raised two or three feet before Mr. Gilbert received charge of the building.

12. According to Mr. Gilbert's statement, the cracks first appeared in Government House on the 19th September 1880, the day after the landslip: but as cracks appeared at the same time in many other houses in the locality, the cracks in Government House seem to have attracted no particular attention. These cracks, however, increased, till in the beginning of 1883 the condition of the house was believed to be unsound; but the report of the Committee of April 1883 appears to have restored confidence, and although in 1889 the question of the subsidence along the Government House ridge was raised, there is nothing on record between that time and October 1894 to show that the cracks in the building caused any grave anxiety. So late as the beginning of 1894 there was a proposal to add new staff quarters to Government House at a cost of Rs. 20,000 to Rs. 25,000. This proposal would hardly have been entertained had there been any real apprehension of the failure of the main building at an early date.

13. Regarding the cause of the cracks in Government House, the Committee hold the same opinion as that expressed in the report of 1883, *viz.*, that they were originally caused by the disturbance of the hill during the cyclone of September 1880. Further, the Committee believe that the cracks have continued to increase, owing to a vertical movement in the front part of the site of the building, and to the foundations, which are shallow, being affected by climatic influences and defective drainage. There is no good evidence to show that the cracks in the main portion of the building are due to lateral movement of the front portion of the hill towards the south, although there is evidence of a local movement of the ground at the east end of the house, where settlement and extensive lateral disturbance have occurred in parts of the building that are structurally unimportant, *viz.*, the east verandah and the conservatory. But, as stated in paragraph 6, the Committee are of opinion that the excessive local movement and subsidence of the site at the south-east corner may be largely attributed to the defects in the drainage system already alluded to.

14. Regarding the important question which the Committee have been asked to consider, *viz.*, the safety of Government House, the object being to ascertain if it is desirable that it should continue to be occupied as a residence, they consider that the question of the safety of Government House cannot be separated from the larger question of the general stability of the hill on the top of which Government House is built. It will be convenient to deal with the matter under two heads:—

(a) The general stability of the Government House hill.

(b) The safety or stability of Government House as a building and the stability of its local surroundings.

15. In dealing with the former question the Committee have given it their grave consideration. Appended to the report is a section of the hill on a natural

scale 40 feet to an inch, taken along the central profile of the spur from Government House, through St. Loe grounds, past Edge Hill and Messrs. Murray's Shop to the Lake. This section shows that the hill from Government House to St. Loe badminton court, a horizontal distance of 400 feet, slopes at an angle of 35° .

Through St. Loe ground on to the Middle Mall, distance 400 feet, the slope is 20° in the first 200 feet and 28° in the lower 200 feet. From the Middle Mall to Edge Hill, distance 200 feet, the slope is 35° , including an artificial cutting, 40 feet long, behind the house, which has a slope of 45° . Below Edge Hill to the third crossing of Colvin Road, distance 300 feet, the natural slope is 36° ; and from the latter point to 40 feet below the fifth crossing of Colvin Road, distance 300 feet, the slope is 32° . Thence on to the Lake, a distance of 400 feet, there is a gentle average slope of 15° .

The horizontal distance from the edge of the hill immediately in front of Government House to the bottom of the slope beyond the lowest crossing of Colvin Road is 1,600 feet, the corresponding difference in height being 980 feet, thus giving a mean slope of $31\frac{1}{2}^{\circ}$ for the steep portion of the hill. The total distance of the same edge to the Lake is 2,000 feet, and the height of Government House plateau above the Lake is 1,080 feet (see also small section, figure No. 1, drawn to scale). The slope reaches 35° and 36° for more than half the length of the steeper portion of the hill. The Committee find that the angle of repose of slate shingle washed down the side of the hill above and below the Upper Mall, east of Stafford House, is 38° . This agrees with Rankine and other authorities.

Experience shows that hills at Naini Tal consisting of underlying slate and having a soil cap of disintegrated slate or shale stand well at angles of 35° to 40° , where surface drainage is attended to and the toe of the hills is not subject to erosion.

16. The attention of the Committee has further been given to a consideration of the irregular crack which passes through the Government House plateau, the St. Cloud, Snow View, and Alma Lodge compounds. The cause of the crack has never been satisfactorily explained, nor its growth properly observed or recorded. It is reported to have first appeared in September 1880 and to have since shown signs of opening after the rains of each year. The opening after the rains of 1894 is said to have been considerable. The crack is thus known to have been in existence for at least fifteen years, and there is nothing to show that it has not been in existence for a much longer period.

Whatever movement there may have been, has been slow and in the Committee's opinion no immediate apprehension for the safety of the Sher-ka-danda hill need be felt on account of the existence of this crack. Steps should, however, be taken to record any further movement that may take place in the future.

17. The Committee think it possible that the recent alarm about Government House and Sher-ka-danda hill may have been intensified by the accounts of the Gohna Landslip of October 1893. In their opinion, however, a knowledge of the circumstances under which the Gohna Landslip occurred and of the precipitous nature of the face of the hill should, on the contrary, tend to allay such fear regarding the stability of Government House hill. The accompanying section, figure No. 2, copied from Mr. Holland's Report on the Gohna Landslip, to which has been added for comparison a section of the Government House hill, Naini Tal, shows the hill which fell at Gohna and illustrates the different conditions of the two cases. The profile of the Government House hill, Naini Tal, has a slope of 35° to 36° at its steepest points, while at Gohna the slopes before the slip took place cannot have been less than from 45° to 60° .

During the course of their observations the Committee were much struck by the beneficial results of the drainage improvements that were carried out

The result of the observations should be recorded on proper forms in a strongly bound register, the name of observer and date of observation being invariably entered. The register should be maintained in duplicate.

There should be a separate page for each point, level, or measurement, in which the result of observations will be entered in rotation for easy comparison.

- (10) The badminton ground at St. Loe Cottage site should be sloped off as nearly as possible to the original angle of the hill.
- (11) The tennis court belonging to Durga Sah near west entrance gate of Government House should be levelled off, the same as at St. Loe Cottage.
- (12) The lawn tennis and badminton courts in St. Loe grounds to be covered with 6 inches of well rammed limestone metal broken to $1\frac{1}{2}$ gauge, mixed with 8 per cent. of good clay, and laid to a slope of 1 in 200 on the actual tennis courts and 1 in 100 outside this area. The tennis court area to be finished off with fine line concrete, or in any other manner desired. The whole to be well drained by surface channels delivering into suitable outfalls.
- (13) *In order to test by accurate observations from outside points whether there is any movement in the Government House hill, stations should be selected on the Cheena slope at convenient points, such as Fairlight Hall (Tonnochy's), Jesmond Villa, and perhaps the Upper Mall, from which a point in Government House hill and one or more points on the adjacent hills in the same vertical plane can be observed. For instance, a black vertical line can be painted on an outhouse near the Club, another on an outhouse west of Edge Hill, and a third on the main building of Oak Openings, which would all be in the same vertical plane as a theodolite station at Jesmond Villa. At least two stations of this nature should be selected. The theodolite stations should be chosen and prepared at once. The exact position of the instrument should be fixed by a mark cut on a block of Nalena stone built into a masonry base.*
- (14) Pillars of masonry should be built at selected points on each side of the crack along Government House ridge, for observing any movement which may take place along the crack during and after the rains.
- (15) In order to keep a close watch on the working of the surface drains and to remedy any defects at once, a competent Sub-Overseer should be constantly employed at Government House for this purpose, from the 1st of June till 1st November.

J. S. BERESFORD.

R. R. PULFORD.

C. PERRIN.

J. R. C. NICOLLS.

W. B. GORDON.

NAINI TAL:

The 11th May 1895.

}

Memorandum by the President on Mr. OLDHAM's dissent, dated the 24th May 1895.

THE last meeting of the Committee was held on the 10th May, when there was a general agreement on all main points and nothing apparently remained but to make a few verbal alterations and additions in passing the report through the press. Since then, however, there has been further correspondence with Mr. Oldham, who submitted a note dated 13th May 1895, commenting on recommendation No. (13) of paragraph 19, and suggesting the omission of this recommendation and proposing the construction of an adit for drainage under Government House. I wrote a memorandum on the 19th idem on Mr. Oldham's note showing why recommendation No. (13) should be retained and dealing with Mr. Oldham's proposal for an adit.

2. I have now received back from the Secretary the draft report, with a final note, dated 24th May, from Mr. Oldham dissenting wholly from paragraph 19 of the report, to which he had previously agreed with the exception of clause (13). In a demi-official letter of the same date addressed to me, Mr. Oldham states :—"I have been over the site and hillsides again. I now think it is too late for an adit to do any good. The movement has been distinctly going on even during the dry weather, and I regard the danger to the site as imminent."

3. I think it undesirable to delay the submission of the report by prolonging the correspondence, but I consider Mr. Oldham should be requested by Government to record in detail the observations on which he has changed his opinion. Mr. Oldham now states that he considers the site of Government House must already be regarded as unsafe during the rains. I can hardly think that any new development of unfavourable conditions has occurred since the Committee carefully inspected the hillside and retaining walls below the site and sounded the holes in the slope immediately south of the flag-staff, and personally I see nothing in Mr. Oldham's dissent of the 24th instant that would alter the decision previously come to by the Committee.

PACHMARHI:

The 29th May 1895.

J. S. BERESFORD,

*Note by MR. OLDHAM on the draft Report of the Committee convened under G. O.
No. 2609, of 22nd April 1895.*

SECTION 19 of this report was not fully discussed at the last meeting, and I find that a recommendation (No. 13) has been added to which no reference was made. As the member of the Committee whom this recommendation particularly concerns, I cannot sign any report in which it is embodied, as I consider the proposals inadequate and the results obtainable from the specific recommendation as unlikely to be worth the trouble of obtaining them. I further object to this as being outside the scope of the reference to the Committee. I consequently suggest that it should be omitted altogether, or replaced by the following :—

(13) "An adit should be driven into the south face of the hill at a convenient spot not less than 75 or more than 100 feet directly below Government House and carried back clear of the buildings. The information regarding the condition of the rock obtained in driving this will decide whether upcast or branch drifts are desirable."

My reason in suggesting this recommendation is that the very extensive proposals adopted by the other members of the Committee, to which in themselves I raise no objection, are, in my opinion, merely palliative and not curative. As I have repeatedly insisted and as is the opinion of some members at least of the Committee, the cause of the mischief is a deep seated one, and I cannot approve of recommendations of so extensive a nature and involving the expenditure of such a large sum of money as they necessarily do, unless at the same time some attempt is made to deal with the cause of the mischief.

The only practicable means are drainage works which will tap the inside of the hill, carry off the water, and so keep the body of the rock dry. The fact that it is only in the rains, when the rocks are waterlogged, that any movement takes place, in itself shows that if we could keep them permanently as dry or nearly as dry as they are for three-quarters of the year, nothing need be apprehended. The only question is whether the actual limit of depth proposed by me is sufficient or not. If on driving the tunnel it is found that the fissures seen at the surface extend to a still greater depth, then the effect of the tunnel may only be palliative, though probably the drainage of even the upper 100 feet of the hill may be sufficient to stop any further movement here and shift it to a lower level. If, on the other hand, the rocks are found to be firm and water-tight, it will be necessary to drive upwards to the more disintegrated stuff. This is, however, a detail.

This single tunnel would of course only be protective of the particular part of the hill on which Government House stands. That it will have a beneficial effect is almost certain, and if the interests at stake are held to be sufficient to justify the expenditure already recommended by the Committee, they seem to me to demand this extra expenditure, without which the other would have no more than a temporary success, if even that.

NAINI TAL :

The 13th May 1895.

R. D. OLDHAM.

Memorandum by the President on Mr. Oldham's Note of the 13th May 1895 on the Committee's Report.

THE recommendation No. (13), paragraph 19 of the report, was discussed by the Committee in a general way, but in the final draft the proposal had to be stated in definite terms. All the members of the Committee are equally interested in any practical investigation that will prove whether there is or is not a general movement towards the lake in the Government House hill, of the nature indicated by Mr. Oldham's report of 1889. The permanent safety of Government House is dependent on the stability of the hill on which it stands: and there would be little satisfaction in declaring the house safe if the hill is in danger. From the nature of the case, the horizontal component of any movement in the hill is likely to be greater than the vertical component; besides, the method of observing horizontal movement indicated in recommendation No. (13) is so much more simple and at the same time so much more delicate in practice than any method that can be applied to the determination of vertical movement that it should certainly give more reliable results.

Vertical movement can be tested only in two ways:—

(a) by means of spirit levelling operations;

(b) by means of a theodolite, involving the accurate determination of at least two vertical angles.

Regarding (a), any one experienced in levelling will admit the great difficulty there is in obtaining accurate results in hilly ground except over very short distances.

Regarding (b), the known error in case of horizontal angles with ordinary instruments is three inches in a mile; the error in respect of vertical angles is much greater owing to the uncertain effect of air refraction.

There are no such drawbacks in the method of observing horizontal movement recommended in paragraph 19 (13) of the Committee's report. It is not even necessary that the plane of theodolite observation should be truly vertical so long as the lines on points observed are all in one plane originally. As many planes of observation may be chosen as may be considered necessary near the top, the middle, or the base of the hill, wherever most movement may be expected.

2. Mr. Oldham seems to be mistaken as regards the cost of the measures recommended by the Committee. The under-pinning of the walls of Government House, the heaviest item and one not likely to be carried out at once, would be Rs. 3,000. The cost of the other proposals in connection with the building will not aggregate over Rs. 2,000. Metalling the St. Loe tennis courts is a separate work and would cost about Rs. 75 per 1,000 square feet.

3. Regarding Mr. Oldham's proposal to drive an adit from the south side of the hill directly under Government House at a depth of 75 to 100 feet below foundation level. The length of the adit would be about 300 feet, and its section would require to be $5\frac{1}{2}$ feet in height by $4\frac{1}{2}$ feet in width, to give room for working and for fixing props and roof boards if necessary. The cost would be at least Rs. 5 per foot run or say Rs. 1,500 to Rs. 2,000 in all to begin with. The value of the adit as a drain would be estimated hereafter by the volume of water which would flow out of its mouth during and after the rains. In my opinion, and in that of several members of the Committee, the drainage effect of such an adit would be trifling, if any. The important point is to prevent water from entering the hill as far as possible and not to encourage its circulation through the body of the hill. The construction of the proposed adit would, however, increase our knowledge of the interior of the hill and show whether the fissure in the plateau extends to the depth assumed, and if the

local officers consider that an adit 250 to 300 feet long can be made for Rs. 1,500, the experiment might be worth the cost. The excavation from the adit would amount to 7,500 cubic feet of solid rock or shale, and say 10,000 or 12,000 cubic feet of loose stuff, which would have to be carried to the north side of the hill or to St. Loe Gorge.

PACHMARHI :
The 19th May 1895. }

J. S. BERESFORD.

Copy of Mr. OLDHAM's dissent, dated 24th May 1895.

I CONCUR, except with section 19, from which I dissent as a whole, though accepting the recommendations in detail, if it is finally determined to maintain the house. The measures recommended to protect the house from further deterioration, being all devoted to dealing with the surface drainage of the house and immediately surrounding site, would have the desired effect if the subsidence and fractures which have been noticed were merely due to the access of rain water to imperfect foundations. As I am convinced that the surface drainage of the site of the house is only a minor factor in determining the movements which have taken and will take place, I cannot accept this scheme as completely protective, or even assent to the statement that on the observed results must depend the eventual decision as to the permanent retention of the house as a residence. If nothing more can be done, its abandonment will have to be faced very soon.

At the time of the last meeting of the Committee I was prepared to advocate a measure which I then believed would attack the real cause of the mischief; a further examination of the hillside and site has led me to believe that the time has passed when this would be of any use, and I now consider that the site of Government House, apart from any question of the stability of the structure, must already be regarded as unsafe during the rains.

NAINI TAL: }
The 24th May 1895. }

R. D. OLDHAM.

Memorandum by the President on Mr. OLDHAM'S dissent, dated the 24th May 1895.

THE last meeting of the Committee was held on the 10th May, when there was a general agreement on all main points and nothing apparently remained but to make a few verbal alterations and additions in passing the report through the press. Since then, however, there has been further correspondence with Mr. Oldham, who submitted a note dated 13th May 1895, commenting on recommendation No. (13) of paragraph 19, and suggesting the omission of this recommendation and proposing the construction of an adit for drainage under Government House. I wrote a memorandum on the 19th idem on Mr. Oldham's note showing why recommendation No. (13) should be retained and dealing with Mr. Oldham's proposal for an adit.

2. I have now received back from the Secretary the draft report, with a final note, dated 24th May, from Mr. Oldham dissenting wholly from paragraph 19 of the report, to which he had previously agreed with the exception of clause (13). In a demi-official letter of the same date addressed to me, Mr. Oldham states :—"I have been over the site and hillsides again. I now think it is too late for an adit to do any good. The movement has been distinctly going on even during the dry weather, and I regard the danger to the site as imminent."

3. I think it undesirable to delay the submission of the report by prolonging the correspondence, but I consider Mr. Oldham should be requested by Government to record in detail the observations on which he has changed his opinion. Mr. Oldham now states that he considers the site of Government House must already be regarded as unsafe during the rains. I can hardly think that any new development of unfavourable conditions has occurred since the Committee carefully inspected the hillside and retaining walls below the site and sounded the holes in the slope immediately south of the flag-staff, and personally I see nothing in Mr. Oldham's dissent of the 24th instant that would alter the decision previously come to by the Committee.

PACHMARHI :

The 29th May 1895.

J. S. BERESFORD,

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APPENDIX A.

PLUMBINGS OF WALLS AT GOVERNMENT HOUSE, NAINI TAL.

The 25th April 1895.

NOTE.—The positions of the plumbings on ground floor are marked in red encircled numbers on plan No. 2 accompanying.

Ground Floor.

No.	1 wall leans	$\frac{3}{8}$ inch, southwards in a height of 10 feet.		
2	ditto	$\frac{1}{2}$ "	ditto	10 "
3	ditto	$\frac{1}{4}$ "	ditto	12 "
4	ditto	$\frac{1}{4}$ "	ditto	12 "
5	ditto	1 "	ditto	10 "
6	ditto	$\frac{1}{8}$ "	ditto	10 "
7	ditto	1 "	ditto	12 "
8	ditto	$\frac{1}{4}$ "	ditto	14 "
9	ditto	$\frac{3}{4}$ "	ditto	12 "
10	ditto	$\frac{5}{8}$ "	ditto	14 "
11	ditto	$1\frac{1}{4}$ "	ditto	12 "
12	ditto	$\frac{7}{8}$ "	ditto	14 "
13	ditto	1 "	ditto	13 "
14	ditto	$\frac{1}{2}$ "	ditto	13 "
15	ditto	$1\frac{1}{4}$ "	ditto	12 "
16	ditto	1 "	ditto	14 "
17	ditto	$1\frac{1}{4}$ "	ditto	12 "
18	ditto	$1\frac{3}{4}$ "	ditto	13 "
19	ditto	$\frac{1}{2}$ "	ditto	13 "
20	ditto	$1\frac{1}{2}$ "	ditto	13 "
21	ditto	$\frac{1}{4}$ "	ditto	13 "
22	ditto	1 "	ditto	13 "
23	ditto	$\frac{3}{8}$ "	ditto	13 "
24	ditto	$\frac{3}{4}$ "	ditto	13 "
25	ditto	$\frac{3}{4}$ "	ditto	13 "
26	ditto	$\frac{1}{2}$ "	ditto	13 "
27	plumb			
28	wall leans	$\frac{1}{2}$ inch, southwards in a height of 12 "		
29	ditto	$1\frac{3}{8}$ "	ditto	12 "

First Floor.

Upper Corridor—East end.

North wall leans $\frac{1}{4}$ inch northwards in a height of 10 feet.
 South ditto 2 inches southwards ditto 10 "

Upper Corridor—West end.

North wall near stairs leans $\frac{1}{4}$ inch southwards in a height of 10 feet.

South wall plumb.

Loft (roughly plastered).

East end.

North wall leans $1\frac{1}{2}$ inch northwards in a height of 8 feet.

South ditto 1 ,, southwards ditto 10 ,,

West end.

North wall leans 1 inch southwards in a height of 8 feet.

South ditto $\frac{3}{4}$,, northwards ditto 10 ,,

F. O. OERTEL,

District Engineer.

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APPENDIX B.

INQUIRY INTO CONDITION OF GOVERNMENT HOUSE.

Naini Tal, the 17th April 1895.

To—MR. J. DOCHERTY.

PLEASE say how long you were in charge of the building operations and give some information about the following points:—

(1) Were there any cracks or fissures in the ground before the foundations were put in? If so, please describe them to the best of your remembrance, indicating the position of the main cracks.

(2) How did you deal with these cracks in building the foundations? Were they filled in with concrete, or what?

(3) Do you know when the cracks first showed themselves in the masonry of the building? Some say after the great landslip in September 1880, but there is reason to believe that they began to show even before that.

(4) When was the new Government House first occupied?

Extracts from MR. DOCHERTY'S replies, dated the 17th April 1895.

I HAVE just received your letter about Government House foundations.

(1) Yes, there was a crack right along the whole length of the bungalow, in a line with a large oak or banj tree near the tennis court, and it came into what is the ladies' boudoir, the back corner, then it went into the passage and along it, and crossed the hall, through the conservatory and through the drawing room, in line with a large rhododendron tree opposite the door of the room. The crack was sloping to the west, and a plumb bob with a line would go down 40 feet in some places, in others the crack was only an inch wide.

(2) There were 6 inches of concrete put in where the walls crossed the cracks. That was all that was done.

(3) Yes, cracks took place in the arches in the passage leading from the boudoir to hall, at both sides of the hall. After the landslip, of course, the cracks showed in the floors all along the line of the crack, and in the dining room a bad crack was in the wall. The cause of it was a soft piece of the shale rock. The ground above it had been used for an ice-house, and for 7 feet wide it was so soft I could shove my stick 3 feet deep into it. I wanted piles to be driven in, but Mr. Lawder said concrete was all that was required for it.

(4) The house was occupied in April 1880. I was employed at Government House works during the building of the house, and I did all I could to get Mr. Lawder to put the house back 30 feet; he said I was a fool, that it could not be seen from the Assembly Rooms. I said when people got up, they would think more of it. I wanted him to put 24 logs one at each side of the cracks, filling in between with concrete, and 24 planks (well tarred) on the top. If that had been done, no settlement would have taken place. There is no fear of the hills or Government House. I was employed for two years after 1880 under Mr. Willcocks on the drainage works and know that there are good rocks in the hill.

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APPENDIX C.

INQUIRY INTO CONDITION OF GOVERNMENT HOUSE.

Naini Tal, the 22nd April 1895.

To—H. W. GILBERT, Esq., *Assistant Engineer.*

(1) Were there any cracks or fissures in the ground before the foundations were put in?

(2) If so, please describe the position of any crack you may recollect.

(3) What steps were taken to secure the foundations where the walls crossed the cracks?

(4) When did the cracks in the walls of the building first show themselves? Some say they appeared at the time of the great landslip in September 1880, but there is reason to believe that they may have shown before that; in fact, I should say that the first rainy season after the masonry and plaster were complete might have brought them out.

(5) What effect had the great landslip of 1880 on Government House?

Extracts from Mr. GILBERT's replies, dated the 25th April 1895.

When I relieved Mr. Crompton in January 1879, the foundations of Government House at Naini Tal had been laid, the plinth had been built, and the superstructure raised about an average of two or three feet all round. So that I knew nothing, neither did I learn anything, during the three years I was in charge of Government House, regarding the fissures in the ground now referred to. In April 1880 the house had so nearly approached completion that Sir George Couper occupied it.

Before the great landslip of 18th September 1880, I observed no cracks due to settlement or to any other cause; but when on the following morning Mr. Ashhurst (the Executive Engineer) and myself went over the building, we found

six cracks in the floor of the corridor turning to the left as you enter the hall; there were also some cracks in the covered way leading to the Staff Quarters. As the flooring was done with Portland cement, the cracks were very conspicuous and admitted of nearly correct measurements, which I remember well aggregated six

* NOTE.—The aggregate width of six inches mentioned by Mr. Gilbert must be a mistake. He may mean half an inch instead of half a foot. The Committee of 1880 inspected Government House informally one afternoon; but I have no recollection of the size of the cracks referred to; they must have been trifling, however. I remember the level of the floor was tested by pouring water on it in the hall. The water flowed towards the front door.

The 3rd May 1895.

J. S. BERESFORD.

inches.*

The entrance to the corridor on the left was effected by passing under an Elizabethan archway, the keystone of which had slipped down about four inches. This I remedied by prising up the keystone, and wedging it in position with some hoop iron rolled in fillets of lead and tightened by spauls.

On an examination of the grounds we found that there was a distinct crack all round the flagstaff, forming the segment of a circle, with a radius of about 30 feet.

What struck me very forcibly was that the cracks which I had traced upon the general ground plan of the building, subsequently placed before Colonel Brownlow's Committee, of which Mr. Beresford was a member, exhibited an extraordinary parallelism, crossing the meridian almost at right angles, and that there were no cracks running transversely that came under my observation.

I also noticed that several of the zinc sheets covering the roof were brought into a state of tension, and some in the angle formed by the library and the conservatory were strained diagonally.

As a measure of precaution I placed marks across the cracks 12 inches apart, and measured them constantly, with the result that I found them increasing steadily up to February 1882, when I left Naini Tal. I reported this to the Executive Engineer.

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SECTION ACROSS THE BIRAH GANGA VALLEY

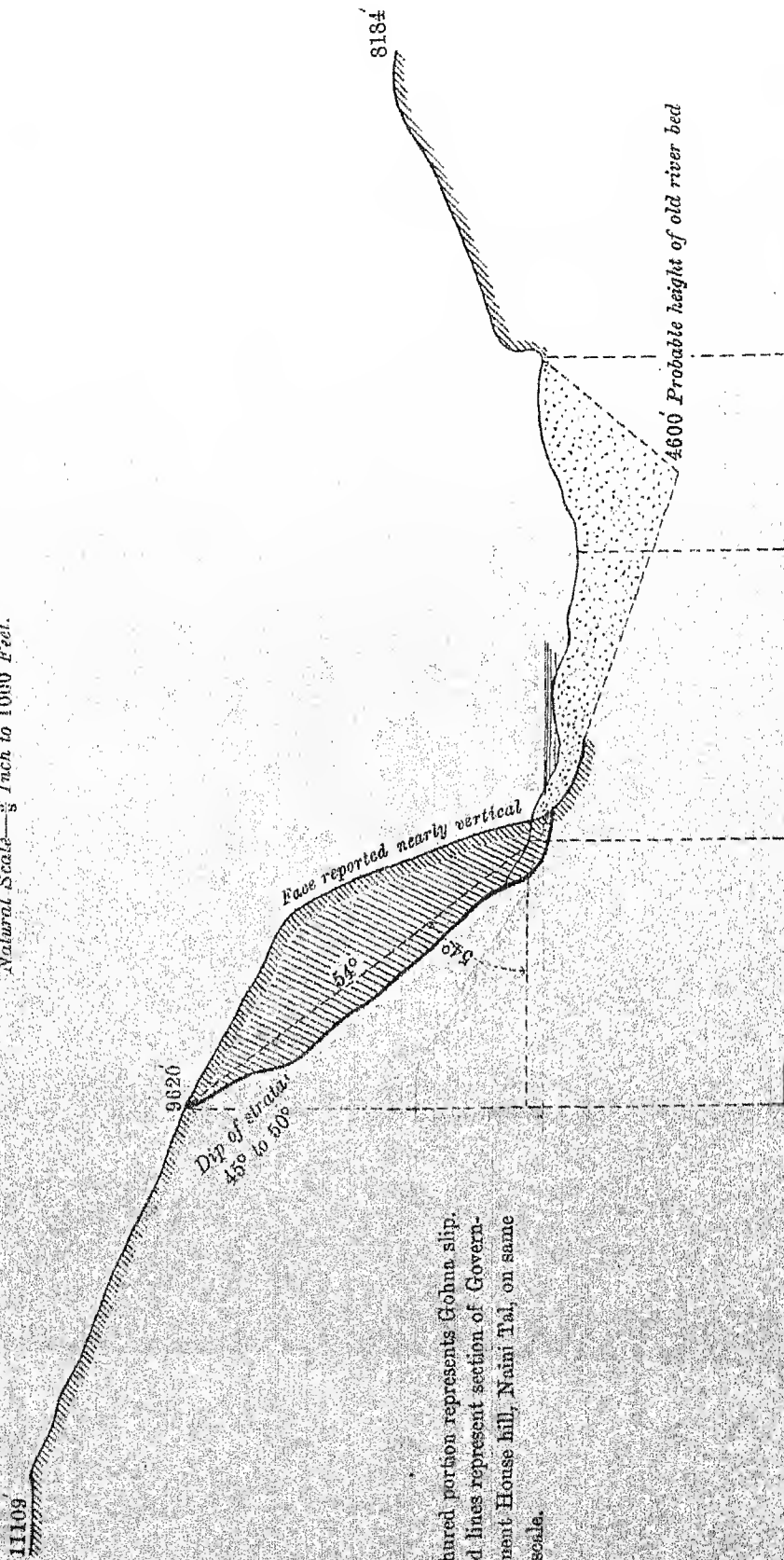
at

GOHNA, GARHWAL, SHOWING LANDSLIP OF 1893,

together

SECTION OF GOVERNMENT HOUSE HILL, NAINI TAL.

Natural Scale— $\frac{1}{8}$ Inch to 1000 Feet.

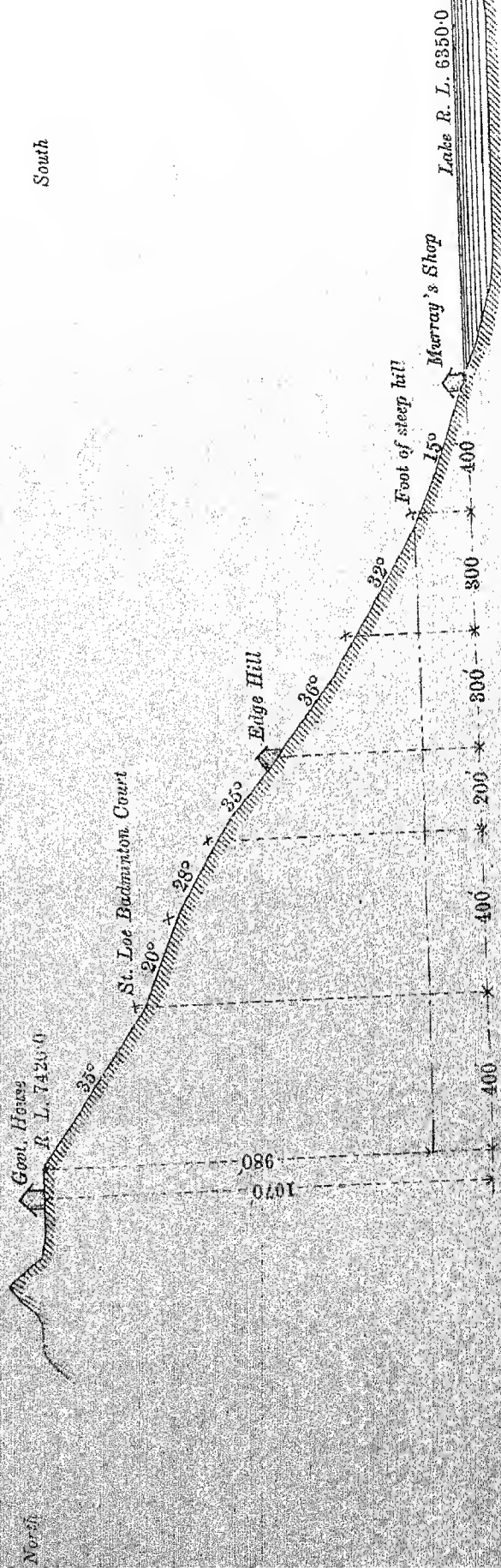


Note.—Hatched portion represents Gohna slip.
Red lines represent section of Government House hill, Naini Tal, on same scale.

F. O. OERTEL, Executive Engineer,
Secretary.
12th May, 1895.

SECTION OF GOVERNMENT HOUSE HILL, NAINI TAL.

Natural Scale—1 Inch to 400 Feet.



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No. 3745 W.A. of 1895.

GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
BUILDINGS AND ROADS BRANCH.

DATED NAINI TAL, THE 8TH JUNE 1895.

FROM

J. G. H. GLASS, Esq., C.I.E.,
SECRETARY TO GOVERNMENT, N.-W. P. AND OUDH,
P. W. DEPT., BUILDINGS AND ROADS BRANCH,

TO

R. D. OLDHAM, Esq.,
SUPERINTENDENT, GEOLOGICAL SURVEY OF INDIA.

SIR,

THE proceedings of the Committee which assembled, under G. O. No. 2609, of the 22nd April last, to consider the safety of Government House, Naini Tal, and of which you were a member, have just been received from the Secretary of the Committee.

2. From your note, dated the 24th May, it is observed that, though you concur in the report with the exception of section 19, from which you dissent as a whole, you state that you consider that the site of Government House must be regarded as unsafe during the rains. You give no reasons in support of this view, and I am directed to ask that you will be good enough to inform Government on what grounds you condemn the site. I am to remark that the opinion of a geologist of your standing and experience must carry great weight in a question of this kind, and that should your views be accepted by Government, it may be necessary to warn people occupying houses on the same hill below Government House that apprehensions of an immediate catastrophe (that is, during the coming rainy season) are entertained, and that they must vacate without delay. Your opinion may not, however, refer to any part of the hill below Government House, and should that be the case I am to ask that you will be good enough to say if, in your opinion, the houses on the hill below Government House, as also those on the same ridge, may continue to be occupied with safety. The favour of a very early reply is requested, as the matter is one with which it is necessary to deal promptly.

I have the honor to be,

SIR,

Your most obedient servant,

J. G. H. GLASS,

Secy. to Govt., N.-W. P. and Oudh,
P. W. Dept., B. and R. Branch.

Dated the 11th June 1895.

From—R. D. OLDHAM, Esq., *Superintendent, Geological Survey of India,*

To—HON'BLE MR. J. G. H. GLASS, C.I.E., *Secretary to Government,*
N.-W. P. and Oudh, P. W. Dept. (B. and R. Branch)

SIR,—With reference to your No. 3745W.A., dated 8th June, in which you ask for the reasons for which I consider the site of Government House unsafe during the rains. These reasons are to some extent of a technical nature, which could only be properly explained at great length and as part of a detailed treatment of an extensive field of investigation. Briefly, they may be said to be a comparison of my recent and former observations of the hill with the known and well established order of events which has been observed to precede a landslip on hills of a similar nature to that we have to deal with. Under such circumstances it has been found that there is a general downhill movement of the more or less disintegrated rock near the surface. At first this is fairly general and ill-defined, but after a certain stage has been reached a definite line of weakness is established across the upper limit of the coming slip, along which the separation and subsidence of the hill is most conspicuous. At the same time lines of weakness, marking the lateral limits of the future landslip, are generally established down the slope of the hill, along which shearing takes place. In the area so defined other minor and more irregular fissures and deformations of the slopes are found; but as the whole hillside is moving, they are not so conspicuous as where there is a well marked limit between the part which is moving and that which is comparatively stable.

2. The lateral lines of shearing, which run down the hill side, are not only much less well marked as a rule than the transverse fissures at the top, but their observation is rendered more difficult by the effect of any movement that may take place being much less conspicuous and by the ease with which the signs are obliterated by rainwash. I believe, however, that something of this kind may be recognised in the ravine between St. Loo and the Staff House, where the drain built in 1880 has been considerably deformed by numerous cracks, all of which show a transverse shearing of the drain as a whole. The transverse fissuring at the head of the future slip is, however, well marked; my attention was drawn to it in 1889, when I reported that the matter was a serious one, but need not be the cause of immediate apprehension. Had I then any suspicion of the very rapid development which would take place in the next five years, I should have used somewhat different language. Comparing the present condition of this line of fissuring and separation of the hillside with what it was in 1889 and 1890, it seems to me, apart from any other consideration, that the end cannot be deferred for many more years.

3. Had this hill never been interfered with, I anticipate that there would ultimately have been a large landslip extending from near the St. Loo gorge to near Alma; but the hill has been largely interfered with, and the result of this is that events have developed most rapidly and the danger is most pressing at the Government House end of the ridge. Such at least appears to be the case, though there is a possibility that the appearance of greater danger may be due to the greater facility of observation here as compared with the same ridge further west. The difference, however, does not appear to be solely or even largely attributable to this cause, and it is in the neighbourhood of Government House and immediately to the west that the opening of the fissures and the differential movement of the ground is most conspicuous. The bare rock exposed under the flag-staff is traversed by several gaping fissures, and all down this hillside as far as the St. Loo grounds, wherever there is an exposure of rock, it is seen to be full of open fissures, pointing to a general deformation of the surface and an unstable condition of the hillside.

4. These appearances alone would lead me to regard the hill as unsafe, but in addition to them I find that the movement of the hill, as indicated by the opening of cracks in the walls of the house and retaining walls in the grounds, is no longer confined to the latter part of the rains, when the rock is waterlogged, and consequently the impulse due to gravitation at its greatest and the frictional resistance at its least. On the 21st May I noticed that cracks had opened in the dining room wall, which had not been noticed when the house was inspected by the Committee, and must certainly have opened since the wall was papered in April. It has been suggested that the opening of the cracks both in the house and in the ground is due partly or entirely to a shrinkage of the rock by drying; that they are in fact analogous to the cracks which open in alluvial soil in dry weather. There is, however, no evidence to show that any such expansion and contraction takes place in the slate rock of which the hill is composed, and it seems more natural to regard them as due to that general movement of the outer part of the hill which is indubitably going on. I have further noticed that after the rain of the night of the 6th June a movement of more than half an inch took place along a fissure which runs through the retaining wall and across the road under the flag-staff.

5. This movement, taking place at a time when the resistance has not been reduced by the soaking of the whole hill with water, points to the conclusion that the bonds which keep the superficial portion of the hill attached to its core are rapidly being disrupted, and it is to a great extent on this that I based my statement that the site of Government House could no longer be regarded as safe during the rains. It is not outside the bounds of possibility that with a full monsoon a slip may take place within the present year, and in any case movement is to be anticipated to an extent which would make the house undesirable, if not unsafe, for its inhabitants.

6. With regard to the latter part of your letter, though I consider it a mistake to have allowed the erection of the buildings which have sprung up during the last few years on and below the hill under Government House, I do not consider it necessary to order their immediate vacation. Many of these houses have only lately been built or largely extended, and their abandonment would mean a great hardship and serious loss, to which their proprietors should not be unnecessarily submitted. It is by no means certain that they will be exposed to any special danger during the present year, though this is, as I have stated, within the bounds of possibility, and if recommendation (15) of paragraph 19 of the Committee's report is carried out, the Sub-Overseer in charge will be able to notice and report any dangerous movement or disturbance of the hill in time to enable the inhabitants of the houses below to save, at any rate, their lives. With this letter I send an abstract translation of a scheme of watch and warning against landslips which was proposed in Switzerland in 1807, whose adoption with such minor and obvious alterations as are necessary to adapt it to the special conditions of the present case I most strongly recommend. In this way loss of life at least can be prevented without exciting the natural discontent and opposition which would be roused by an order to immediately vacate in view of an event which may not come off for some years.

7. Though, as explained in the last paragraph, I do not consider it necessary to order the immediate vacation of these houses, there are other steps which should be taken without delay. I have noticed, not without some surprise, the rapid and complete oblivion of the lessons of 1880 which appears to have come over the local authorities of Naini Tal. A policy of almost reckless security seems to have replaced the timidity and suspicion which prevailed for many years; numerous buildings have been allowed to spring up, and a thick population to settle at the foot of a hillside that is notoriously dangerous. A grave responsibility attaches to those who have allowed this state of things to arise; it is now too late to undo what has been done, but peremptory orders might well be issued for the strict observance of recommendation No. (6) of paragraph 11 of the report of the Committee of 1880.

and that not only should no new buildings be permitted within the limits there defined or along the foot of this hill eastwards of the landslip of 1880, but that any modification or alteration of existing buildings designed to afford accommodation for an increased number of inhabitants should be strictly forbidden.

I have, &c.,

R. D. OLDHAM.

APPENDIX.

During the discussions in which I have lately taken part, both in committee and outside of it, I have noticed a general tendency to appeal only to the limited experience acquired in the Naini Tal valley and in connection with the Gohna landslip, and a reluctance to accept the result of the extensive experiences of landslips in other countries, and especially in Switzerland. This reluctance is doubtless due to an ignorance of the very thorough manner in which a large number of landslips have been investigated and the extent of the knowledge of the nature of the premonitory symptoms and of the nature and effects of the actual landslips which has been attained. To give some indication of this I append an abstract of a scheme drawn up by Tschärner in 1807. Since then many landslips have been investigated by the leading geologists and engineers of Switzerland and other countries, but no essential addition or modification of the conclusions or recommendations published nearly ninety years ago has been found necessary.

Tschärner's work was originally published in the 'Nene Sammler für Bünden,' a local Swiss publication, which is presumably inaccessible in India. In 1875 an abstract of his scheme of investigation and protection was published by Dr. A. Baltzer, now Professor of Geology at Berne, in the Swiss Alpine Club annual. Of this abstract I give a translation, omitting only some trivial matters and a few passages which refer to administrative measures and are only applicable to the special polity of the Swiss Confederation.

The conditions of the Alps are sufficiently similar to those of the Himalayas to suggest and even demand an application of the experience gained in the one range to the problems presented in the other. Long ago as Tschärner's scheme was drawn up, it may be adopted in its entirety at the present day, and should any general investigation of the hillsides be determined on, no better scheme can be recommended than that which will be found below. The scheme has the further advantage that the whole of the work of collecting information can be performed by comparatively inexpensive subordinate agency, and from the results so obtained conclusions can be more rapidly and certainly arrived at by superior and more experienced authorities than they would be able to attain by their own necessarily more limited personal examination.

R. D. OLDHAM.

Translation of Abstract.

In addition Tschärner makes some remarks on the timely recognition, prevention, and precautions against such occurrences, which are still deserving of attention.

His remarks, in the first place, that the diversion of rain, spring, and snow water from hillsides where it sinks into the ground is the best means of averting such calamities. How careless people still are in this matter is shown by the case of the Sonnenberg landslip.

Should fissures in the surface, subsidences, and such like occur in any place, they cannot fail to be noticed by hunters, herdsmen, or other people working on the hillside, who should give immediate notice of the same.

Apart from this it would be well for every magistrate in a mountain region to have the whole of his district examined by a couple of men, one of whom should be of the locality and of professional experience, even where there is no indication of danger from slips. Such procedure should in any case not be neglected where there is the slightest suspicion of future landslips.

These subordinates should receive detailed and distinct instructions regarding their duties. With reference to landslips they should—

- (1) traverse the whole commune and enquire whether there are fissures in the soil or rock, distinct depressions, or spots where subsidence has taken place ;
- (2) enquire whether such are new or of ancient origin ;
- (3) observe where standing water, swamps, and marshes occur, and how they originate ;
- (4) follow the surface from the suspicious spots down to the valley, in order to see whether the soil cap is loose and how thick it is, to determine the nature of the foundation on which it rests, whether this has a steep or gentle slope, and whether the slope is continuous or broken into terraces ;
- (5) investigate the connection of the various suspected places with each other, and their direction with regard to each other and the valley ;
- (6) determine the slopes of the suspected spots ;
- (7) determine the places at which spring, rain, and snow water disappears, what course it may take underground, where it re-appears from time to time, and where it finally escapes at the foot of the hill ;
- (8) observe as accurately as possible the depth of any fissures which may occur in the rock, whether and with what they are filled, and especially whether and how far the disrupted part of the hill has been displaced from a position of equilibrium.

These observations should be accompanied by detailed sketches and maps, and the report conclude with a decision on the following, among other, points :—

- (a) whether true landslips are to be apprehended immediately or in the future ;
- (b) what parts of the hills and of the adjoining valleys are threatened ;
- (c) how this danger arises ;
- (d) where the coming landslip probably commences: the length, breadth, and depth of the mass in motion ; of what it consists ; how far it will be able to advance into the valley, and how great a width it may there extend over ;
- (e) how soon at the earliest the catastrophe may be apprehended ;
- (f) by what arrangements it may be opposed ;
- (g) for how long may it be averted or delayed by these arrangements ;
- (h) how it may be rendered as little harmful as possible.

This investigation must not be regarded as final; suspected places should be re-examined yearly after the spring thaw and in autumn and compared with the previous surveys and sketches. Changes must be recorded and a fresh decision arrived at.

As regards prevention, Tschärner lays stress on the removal of in-soaking water by wooden troughs or masonry drains. Rock fissures should be cleaned out and protected by roofing from the entry of water, earth, and stones. He considers, too, that it is possible under certain circumstances to remove a detached portion of the hill from its dangerous position by artificially produced gradual and partial falls, and so to render the slip largely or entirely innocuous.

Regarding the nature and method of the measures to be adopted in the face of an imminent landslip, Tschanner remarks as follows. With proper arrangements no such case can come to pass without being foreseen. (It is in consequence of the neglect of such arrangements that the catastrophe as a rule is unexpected.) Should the annual examination show that the danger is great enough to necessitate greater vigilance, the inspections can be made more frequently or even some resident in the neighbourhood of the dangerous locality be taught and commissioned to observe. In urgent cases a continuous watch may be set.

As soon as the local authorities have convinced themselves, by trustworthy reports and personal inspection, that a danger of this nature is imminent, it becomes their urgent duty to induce the inhabitants of the neighbourhood in question to remove their dwellings to suitable situations. Building materials must be collected, and all movable property removed to the new settlement. Alarm signals (guns or bells) must be concerted, to enable the inhabitants to save themselves in case of pressing danger.

Note by J. S. Beresford, Esq., Chief Engineer, C. P.

—10:—

MR. GLASS has forwarded to me a copy of Mr. Oldham's letter of 11th June 1895 for any remarks I may wish to make thereon.

2. To begin with, I would observe that, in my opinion, there is no profound geological question involved in consideration of the stability of the Government House hill or in that of the immediate site of the building, and therefore the second sentence of paragraph 1 of Mr. Oldham's letter appears to be unnecessarily mysterious, for, although it is suggestive that there are some abstruse reasons withheld which cannot be given in a short compass, yet in the remainder of this paragraph and in paragraphs 2 and 3 Mr. Oldham states fairly the whole theory and observation on which his conclusions are based, and I believe there is really nothing of importance left untold. The body of the hill, as may be seen from the outcrop on the north side and from observations over the slope, consists of strong slate, with a dip of 30° to 35° . On the surface there is a covering, 20 to 40 feet thick, of rock in different stages of disintegration. Now this top layer or soil cap is not of a plastic nature; in some places it is a granular mass, in which term I include gravel and shingle. In most places, however, the original lines of stratification and planes of cleavage are distinctly visible, and the mass can be cut through to a considerable depth with vertical faces that will stand for some time. This temporary cohesion is not due to an intermixture of clay, but to the regular bedding of the small flakes and pieces of disintegrated rock. As a matter of fact, there is no clay to be found on the hill. The puddle required for covering tennis courts and house sites has to be brought at great expense from Rannee on the opposite hill and other places at a distance.

The soil cap not being of a plastic nature, its final stability is entirely dependent on frictional conditions, so that the problems involved are really of a comparatively simple nature. There is not the complex action that has to be considered in dealing with the internal stresses in a large mass of plastic clay or with the flow of a glacier. The only disturbing influence is an excessive ingress of water, and the pith of all remedial measures connected with the hill is facilitating the discharge of surface drainage.

3. I gather from paragraphs 1 and 2 of Mr. Oldham's letter that the idea of a general movement of the hillside is chiefly based on his observations on the crack along the ridge. This crack was brought to Mr. Oldham's notice in 1880, and after inspecting the crack again in 1889 he formed the opinion that it was the indication of a deep-seated fissure in the hill, along which an enormous mass was moving. In discussing this matter at the recent Committee it was shown that certain well known physical conditions seemed to preclude such a movement taking place, and it appears Mr. Oldham has since modified his views on the subject, as in the letter under reference he describes what is happening as "a general downhill movement of the more or less disintegrated rock near the surface." The position of affairs is therefore, according to Mr. Oldham, as follows:—A continuous layer of soil cap, 20 to 40 feet thick, extending from the top of the hill to the lake, a length of 2,300 feet along the slope, is now in a state of general downhill movement. Now, considering the angle of the hill and the known margin of stability that exists at least along the major part of the slope, the chances against a simultaneous movement of the kind described must be very great indeed.

Further, this evidence of the movement is a crack near the extreme summit of the hill, which has been in existence for at least fifteen years, perhaps much longer, and the width of which is probably nowhere over 2 inches when properly measured. There are no records to show how much the crack has increased since

1889, but it seems rather a stretch of words to speak of rapid development. The local fissures referred to by Mr. Oldham are, I consider, no indication of a general movement of the hillside. The cause of this crack along the ridge has not been satisfactorily explained yet, but other causes than a general subsidence of the hill can be suggested. The case stands exactly as described in paragraph 16 of the recent Committee's report, and nothing definite can be stated until a record of the observations now being started is before us. In this connection I would ask a perusal of paragraphs 8 and 9 of the report of the Committee of 1880.

4. The comparison of the observations of 1889 and 1880 with the present condition of things referred to in the last sentence of paragraph 2 of Mr. Oldham's letter must surely be based on recollection or general impression as regards the former two years, and not on actual record? Mr. Oldham, if he examined the Sher-ka-danda hill after the landslip of 1880, must have observed the numerous cracks referred to in the report of the Committee of 1880, especially those alluded to in paragraph 24. No one who carefully inspected the hillside immediately after the landslip of 1880, as the members of the first Committee did, can say that the condition of things now is not materially better than it was then. See paragraph 24 of that Committee's report and the list of cracked and damaged houses in paragraph 29, which give an idea of the numerous cracks that appeared over the hillside at the time. The condition of things generally in 1880 may be gathered from paragraphs 21 to 29 of the report, and this can be compared with the condition at present.

The comparison will, I think, bear out the soundness of the measures proposed by the Committee of 1880. If that Committee had been influenced by the wild rumours that reached them from all quarters or had accepted that every surface crack represented an incipient landslip, nothing practical would have been done; the place would have been abandoned as hopeless. If some of the views expressed in the report were more adverse to the stability of certain parts of the Sher-ka-danda hill than subsequent experience during a period of over fourteen years, including seasons of very heavy rainfall, seem to justify, it must be remembered that the Committee's investigations were carried on with the dreadful experience of an actual and appalling landslip fresh in the mind of every member, and that the report was submitted within three weeks of the occurrence of that catastrophe.

There can be no question that the drains constructed and the various precautions taken after the landslip of 1880 have much improved the conditions of stability of the Sher-ka-danda hill. Less rain water enters the soil cap now, as it is notorious the springs are less in volume. I lived in Glenmore during 1887, one of the driest years on record; yet there was a considerable flow of water all through the hot weather in the ravine on the west side of the house, where the entrance road on the west crosses. In April of this year, 1895, the ravine was quite dry, notwithstanding that there was an unusually heavy fall of 18 inches of rain in October 1894. As there are no new drains above this ravine at Glenmore, the falling off in spring water must be attributed to the better covering of grass and absence of cow tracks and horizontal paths on the slopes above compared with former times when promiscuous grazing was allowed and the short grass and numerous cow tracks and paths greatly facilitated the absorption of rain water by the soil cap. Further, the flow from the lake, so far as records exist, shows that nearly all the heavy rain which falls on the south slope of Sher-ka-danda hill reaches the lake within a few weeks of its fall. Therefore, taking all the known facts of the case into consideration, there is less likelihood of a landslip occurring in Government House hill now than in 1880 and previous years of heavy rainfall.

5. Regarding paragraph 3 of Mr. Oldham's letter. The fissures in the rock below the Government House flag-staff were noticed by the recent Committee; they are by no means new, and being local can, in my opinion, have no important bearing

on the general stability of the hill. There are similar fissures between Snow Seat and St. Cloud, which were considered of no importance; and Lala Krishna Sah, Rai Bahádúr, informed me that such fissures existed on the knoll which covered present Government House site when he played there as a boy. These fissures give one the impression that a portion of the rock has been dissolved away, and they are probably what gave rise to a theory advanced by Mr. Lawder, the Executive Engineer who built Government House, in a letter to the Committee of 1880, *viz.*, that cracks and local subsidence in the hill are due to the presence of iron pyrites in the rock which gets dissolved. If the fissures below the flag-staff were any real measure of the deformation of the hill, there would long since have been very pronounced signs of it in the retaining wall on the road below the flag-staff, whereas all along this wall has stood remarkably well for fourteen years.

The anticipations hazarded in paragraph 3 of Mr. Oldham's letter as to a large landslip occurring in the region referred to are quite a matter of opinion. The evidence on which these anticipations are based seems to me to be very small indeed. Some consideration must be given to the actual slope of the hill, the area of ground, and mass of rock and soil comprised in the region in question compared with a few small superficial cracks that can be accounted for in more ways than one.

6. Regarding paragraph 4 of Mr. Oldham's letter. I should not lay much stress on the cracks in the dining room hall to which he refers. I understand they are in one of the cross walls. There were some small cracks in these walls of which the Committee took little notice, considering them unimportant: some cracks, being papered over, may not have been visible. The opening of the crack in the retaining wall on the road below the flag-staff is a more important matter. This wall, considering its position, is, as already noted, singularly free from cracks. The crack in question should now be gauged in an orthodox manner once a week. Owing to the chance of the pointing or mortar falling out if slight movement or shrinkage takes place, the actual gaping width of a crack is often deceptive. But even the sudden increase of half an inch in the width of a crack in a retaining wall would not justify the total abandonment of a hillside. The increase may be due to purely local causes. In speaking of other causes in this connection the potent effect of temperature must not be overlooked. *A propos* of this subject I append to this note an extract from the *Proceedings of the Institution of Civil Engineers*, volume CXV, pages 107 and 108, containing remarks by Sir Benjamin Baker in a discussion on reservoir dams in November 1893.

7. The condemnation summed up in this paragraph 5 is, I think, far too sweeping, considering the slender and uncertain data on which the conclusion is based.

8. The first part of paragraphs 6 and 7 of Mr. Oldham's letter seems to me to be inconsistent with the advice tendered in the preceding paragraphs. All past experience goes to show that the chief seat of danger is at the foot of the hill. Paragraphs 24 and 26 of the report of 1880 bear on this point. Under the worst circumstances there is little chance of subsoil water collecting to a dangerous extent near the top of the hill; if it accumulates at all, it is only matter of common sense that it would do so most at or near the base. If danger is to be apprehended, then personally I should infinitely rather live on the top of the hill than at the bottom, and to be consistent the occupants of houses on the slope, and especially of those at the bottom, should be warned.

9. I shall refer later on to the concluding sentence in paragraph 6. Turning again to paragraph 7, I must admit it is surprising how soon the people forget the effect of the dreadful landslip of 1880, but it is misleading to speak of the lessons of that catastrophe having been completely forgotten. On the contrary,

every attention was paid to these lessons, and the patent defects of drainage which led to the landslip were speedily remedied and other obvious precautions taken to prevent as far as possible the recurrence of such an event.

Having lived at Naini Tal during the hot season and rains of the four years subsequent to 1880, I know something of how the confidence of the people in the place was restored. They observed the effective manner in which the new surface and main drains behaved during the rains, especially during the rains of 1884, which were nearly as heavy and as concentrated as those of 1880. The result of the improvement was beyond what was expected and was fully appreciated. In a few years new houses sprang up in what was formerly considered a most dangerous situation. It should be noted, too, that the landslip of September 18th, 1880, occurred after a rainfall of 22 inches in 36 hours; but the rain continued through the night of the 18th and till 4 p. m. on the 19th, adding 11 inches more and bringing the total fall in 58 hours up to 33 inches.

10. Referring to the scheme mentioned in paragraph 7 of Mr. Oldham's letter and in the appendix thereto, I am afraid the application of the scheme to Naini Tal would add little to what we already know. After all the pith of Tscharner's recommendations, which Mr. Oldham says cannot be improved on after a further experience and study of nearly ninety years, is to prevent drainage from entering the hill, and this is what we Engineers have been preaching all along.

The observations that subordinates are to make as detailed under eight heads are no doubt very important, but I think most of the information is available for the Government House hill, Naini Tal. The difficulty of the scheme, however, lies in the true interpretations of the observations when made and in giving a correct report and decision under the eight heads (a) to (h). Here is where the element of doubt comes in and where the varying conditions of different localities have to be considered—where, in short, practical experience and local acquaintance with facts are required as well as book knowledge.

11. I have not written this note in any spirit of controversy, but to assist Government in coming to a proper decision by putting the case in as practical a light as possible, as I realize how embarrassing it is when experts differ in the discussion of a serious matter of this kind.

I was at Naini Tal when the landslip of 18th September 1880 occurred. Alma House, in which I was living, cracked, and the hill above cracked, and on the morning of the 19th I moved into Snow View, where I knew the position was quite safe. It was the cracked steep hill above I dreaded in Alma House, not the slope below. Under similar circumstances I should now choose Snow View, St. Cloud, or Government House as safe positions, and when I arranged to come to Naini Tal in 1893, before my transfer to the Central Provinces, I took Alma Lodge, so personally I am not prejudiced against the situation.

PACHMARHI : }
The 21st June 1895. }

J. S. BERESFORD,
Chief Engineer, Central Provinces.

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Extract from remarks by SIR BENJAMIN BAKER in a discussion at the Institution of Civil Engineers in November 1893, on Impounding Reservoir Dams, pages 107-108 of Proceedings, volume CXV.

In all those structures it was very important to remember that all the conditions were not taken into account. Take, for instance, the element of temperature.

When the sun shone on the sloping face of a dam with comparatively cool water inside it, it was well known that masonry would expand; but it would in most cases be so difficult to provide for expansion that Engineers had agreed generally to shut their eyes to the fact. He had kept a bar of concrete 50 feet long for two years, not in a sunny, but in a shady position, and had noted the expansions and contractions. Taking the modulus of elasticity of that concrete bar, he found that if it had been confined there would have been a compression of 12 tons per square foot from the effect of temperature alone.

Supposing the bar had been of the best masonry instead of 6 to 1 concrete, the pressure would have been about 4 times that, or, say, 50 tons per square foot, from change of temperature alone. Of course in a dam the mass of masonry inside would ultimately become of uniform temperature when they got it sufficiently deep from the external faces. There were experiments made sixty years ago in America by building up a maximum and minimum thermometer in a wall 5 feet 6 inches thick, leaving it there twelve months, taking it out and seeing what the range of temperature had been, and it was found to have been about 20°.

That was sufficient indication that in a mass of masonry, with a uniform temperature inside to a depth of some 4 or 5 feet from the outside, heavy stresses on the external face of the masonry necessarily resulted. Therefore, when one professed to calculate maximum pressures on the masonry of a dam to decimals of a ton per square foot, it was necessary to remember that was on the assumption not only of perfect elasticity, but also of perfectly uniform temperature.

If they took account of the change of temperature, they might have local pressures of four or five times that amount; instead of 8.1 tons, it might be 40 tons. Occasionally it was found that there were cracks on the surface from that cause alone; for instance, in Colombo the concrete face of a reservoir wall or dam was fissured in all directions, and it became necessary to shield it from the sun's rays by an earthwork slope. The important influence of temperature changes was well illustrated in an experimental masonry arch built in Paris some twenty-five years ago on which some very valuable experiments were made. Its own weight of about 300 tons produced a pressure on the masonry of about 20 tons per square foot. It was loaded with 360 tons, which gave an additional 22 tons per square foot, making a total of 42 tons. Variations of temperature caused as much difference in the versed sine of the 124-foot span arch as resulted from 40 tons per square foot variation in stress from loading.

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In all those structures it was very important to remember that all the conditions were not taken into account. Take, for instance, the element of temperature.

When the sun shone on the sloping face of a dam with comparatively cool water inside it, it was well known that masonry would expand; but it would in most cases be so difficult to provide for expansion that Engineers had agreed generally to shut their eyes to the fact. He had kept a bar of concrete 50 feet long for two years, not in a sunny, but in a shady position, and had noted the expansions and contractions. Taking the modulus of elasticity of that concrete bar, he found that if it had been confined there would have been a compression of 12 tons per square foot from the effect of temperature alone.

Supposing the bar had been of the best masonry instead of 6 to 1 concrete, the pressure would have been about 4 times that, or, say, 50 tons per square foot, from change of temperature alone. Of course in a dam the mass of masonry inside would ultimately become of uniform temperature when they got it sufficiently deep from the external faces. There were experiments made sixty years ago in America by building up a maximum and minimum thermometer in a wall 5 feet 6 inches thick, leaving it there twelve months, taking it out and seeing what the range of temperature had been, and it was found to have been about 20°.

That was sufficient indication that in a mass of masonry, with a uniform temperature inside to a depth of some 4 or 5 feet from the outside, heavy stresses on the external face of the masonry necessarily resulted. Therefore, when one professed to calculate maximum pressures on the masonry of a dam to decimals of a ton per square foot, it was necessary to remember that was on the assumption not only of perfect elasticity, but also of perfectly uniform temperature.

If they took account of the change of temperature, they might have local pressures of four or five times that amount; instead of 8.1 tons, it might be 40 tons. Occasionally it was found that there were cracks on the surface from that cause alone; for instance, in Colombo the concrete face of a reservoir wall or dam was fissured in all directions, and it became necessary to shield it from the sun's rays by an earthwork slope. The important influence of temperature changes was well illustrated in an experimental masonry arch built in Paris some twenty-five years ago on which some very valuable experiments were made. Its own weight of about 300 tons produced a pressure on the masonry of about 20 tons per square foot. It was loaded with 360 tons, which gave an additional 22 tons per square foot, making a total of 42 tons. Variations of temperature caused as much difference in the versed sine of the 124-foot span arch as resulted from 40 tons per square foot variation in stress from loading.

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No. 3884W.A. of 1895.

GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
BUILDINGS AND ROADS BRANCH.

DATED NAINI TAL, THE 15TH JUNE 1895.

FROM

J. G. H. GLASS, Esq., C.I.E.,
SECRETARY TO GOVERNMENT, N.-W. P. AND OUDH,
P. W. DEPT., BUILDINGS AND ROADS BRANCH,

TO

THE SECRETARY TO THE GOVERNMENT OF INDIA,
PUBLIC WORKS DEPARTMENT, SIMLA.

SIR,

I AM directed to forward, for the information of the Government of India, a copy of the report of the Committee which assembled under the orders of this Government to consider the question of the safety of Government House, Naini Tal, and whether it is desirable that it should continue to be occupied as a residence.

2. The Committee consisted of a President, Mr. J. S. Beresford, Chief Engineer, Public Works Department, and five members whose names are given in G. O. No. 2609W.A., of the 22nd April 1895, a copy of which accompanies the report. It will be observed that, with the exception of Mr. Oldham, of the Geological Department, the Committee are of opinion that Government House is at present structurally safe and may continue to be occupied as a residence by His Honor the Lieutenant-Governor, *vide* paragraph 19 of report. It will, however, be seen that Mr. Oldham does not hold this view, and is of opinion that the site of Government House, apart from any question of the stability of the structure, must already be regarded as unsafe during the rains, *vide* Mr. Oldham's second note dissenting from the report of the Committee dated 24th May (see page 12 of report).

3. In a letter dated the 11th instant, copy of which is forwarded herewith, Mr. Oldham gives the reasons which have caused him to consider the site of Government House unsafe. The matter is of a very serious nature, affecting not only the occupation of Government House, but also the interests of the owners of house property on the same ridge as Government House and on the hill below Government House. If Mr. Oldham's views are correct—and he expresses them with all the authority of a geological expert who has studied the

question of landslips in this country as well as in Europe,—a considerable portion of the most thickly populated part of Naini Tal must be considered to be in a dangerous state. Should the future slip be of the dimensions which Mr. Oldham seems to think probable, the existence of Talli Tal Bazár and of the Brewery would be seriously endangered by the mass of water which it is reasonable to suppose would be ejected from the lake by the landslip.

4. It is desirable therefore, in the interests of Government and of the residents and house proprietors of Naini Tal and of those concerned in the continuance of Naini Tal as a summer resort, that Mr. Oldham's opinion should be considered and tested by another experienced geologist, and I am to ask that the Government of India will be pleased to depute Mr. Griesbach, Director of the Geological Survey, to Naini Tal at a very early date for the purpose.

I have the honor to be,

SIR,

Your most obedient servant,

J. G. H. GLASS,

*Secy. to Govt., N.-W. P. and Oudh,
P. W. Dept., B. and R. Branch.*

ENCLOSURES :

Copy of No. 2609W.A., dated 22nd April 1895.

Copy of Committee's report, dated 11th May 1895.

Copy of Mr. Oldham's letter, dated 11th June 1895.

Copy of No. 1270I., dated 1st April 1895, and Colonel Corbett's Committee report dated 27th March 1895.

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Dated Naini Tal, the 30th June 1895.

From—C. L. GRIESBACH, Esq., C.I.E., F.G.S.,

Director, Geological Survey of India,

To—Secretary to Government, N.-W. Provinces and Oudh, P. W. Dept.,

B. and R. Branch.

SIR,—I have the honor to report, for the information of His Honor the Lieutenant-Governor, that I have examined the Government House hill at Naini Tal and also that I have carefully read the evidence laid down in the proceedings of the Committee on the stability or otherwise of the Government House, lately assembled.

2. In expressing an opinion on the subject I am confining myself entirely to one aspect of the case only, namely, as regards the condition of the hillside itself; the question whether the Government House is safe or not must be left to Engineers to decide.

3. I may say at once that I fully agree with the opinion expressed by Mr. Oldham, that there is considerable danger of landslips occurring on the slopes of the Government House hill, and I think that it should not have been permitted to build on several of the sites below St. Loo for instance. It seems quite probable to me that the joint examination in detail by Mr. Holland and Engineer officers, which has been decided upon, will result in a wholesale condemnation of sites on that hill slope. The probability is that serious landslips will occur there sooner or later, and the only question which remains is—whether such catastrophes may be looked for within a measurable time or not.

This question seems impossible to answer in the absence of really conclusive data.

4. Mr. Oldham considers that the danger is more or less imminent, and bases this opinion on certain observations which he believes indicate a general movement along the south-west face of the Sher-ka-danda hill, quite independent of the ordinary disintegration of the rock produced by rain and weathering, though the latter may ultimately be the direct cause of a slip. I consider, however, that this view is extremely difficult to prove, though there is some probability that such general movement does exist, which may be of the nature of a dislocation along the line now indicated by the "crack," described as running along and more or less parallel with the strike of the Government House hill.

On the other hand, I am not satisfied that the "shearing," which may be observed in the drainage channels, has anything to do with such a general movement, if it exists at all. That may well be connected with ordinary earth-pressure, in the same manner as the various cracks in the retaining walls or revetments along roads and behind houses. Such may indeed be the forerunners of minor slips and should be looked to, but I question whether they could be interpreted to be indications of the general movement hinted at. The site of Government House itself is certainly a point where such a minor slip might take place, which under certain circumstances might be most disastrous to the houses situated below. Precautionary measures should at once be taken, and I still am of opinion that it is not too late to carry out the recommendations set forth in the "Report of the Committee," paragraph 19, in addition to Mr. Oldham's suggestion contained in his note of the 18th May, concerning the construction of an adit some 70 feet below Government House.

5. In conclusion, I wish to point out that I would deprecate any hasty action, for the present at all events: if the decisions of the present Committee were to be considered as final, I might perhaps think that the time had come to condemn the entire south-west slope of the Sher-ka-danda hill as unsafe, which would necessitate not only the evacuation of Government House, but also of all the houses situated below it. But as an arrangement has been made to thoroughly examine all the hill slopes of Naini Tal immediately after the rains, which examination is to be carried out by an officer of the Geological Survey Department, aided by Engineer officers to be selected by the Government of the North-Western Provinces, I would suggest that at present the suggestions of the Committee be accepted and carried out, and the Government House and the other houses on that hill slope be evacuated in case further signs of a downward movement of the surface of the slope be observed, but that otherwise the fate of Naini Tal be decided after the further examination, as suggested, be concluded.

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No. 8W.A. OF 1895.

GOVT., N.-W. P. AND OUDH,
PUBLIC WORKS DEPARTMENT,
BUILDINGS AND ROADS BRANCH.

DATED NAINI TAL, THE 9TH JULY 1895.

RESOLUTION BY HIS HONOR THE LIEUTENANT-GOVERNOR, NORTH-
WESTERN PROVINCES, AND CHIEF COMMISSIONER, OUDH.

READ—

Report of Committee, dated 27th March 1895, appointed by His Honor the Lieutenant-Governor and Chief Commissioner, under Minute dated 3rd October 1894, to examine and report on the stability of Government House, Naini Tal.

Report of Committee convened under G. O. No. 2609, of 22nd April 1895, to consider and report on the safety of Government House as a residence.

Letter No. 3754W.A., dated 8th June 1895, from Secretary to Government, North-Western Provinces and Oudh, Public Works Department, to R. D. Oldham, Esq., Geological Survey of India.

Letter, dated 11th June 1895, from R. D. Oldham, Esq., Deputy Superintendent, Geological Survey of India, to Secretary to Government, North-Western Provinces and Oudh, Public Works Department.

Letter No. 3884W.A., dated 15th June 1895, from Secretary to Government, North-Western Provinces and Oudh, Public Works Department, to Secretary to Government of India, Public Works Department.

Read also—

Report of Committee appointed to enquire into the condition of the Sher-ka-danda hill, Naini Tal, after the landslip of 1880, dated 8th October 1880.

Report of the Committee ordered in G. O. No. 842, dated 25th September 1882, to report on the character and apparent stability of the protective works at Naini Tal carried out in 1880.

Report of the Committee, dated 8th April 1883, appointed under G. O. No. G.1133B.R., of 17th March 1883, to enquire into the condition of Government House, Naini Tal, and to suggest measures for the prevention of further mischief.

Note on the Naini Tal landslip of 18th September 1880 by R. D. Oldham, Esq., with note by H. B. Medlicott, Esq., Director, Geological Survey of India.

Report by H. C. Conybeare, Esq., C.S., on the landslip of 1880, dated 11th October 1880.

Memorandum by R. D. Oldham, Esq., Deputy Superintendent, Geological Survey of India, dated 21st September 1889, on certain matters connected with the stability of the Naini Tal hills.

Resolution by His Honor the Lieutenant-Governor and Chief Commissioner, in the Public Works Department, Buildings and Roads Branch, dated 25th October 1889.

OBSERVATIONS.—In 1880, the year of the landslip at Naini Tal, various cracks were observed in the walls and floors of Government House, which had then been only recently completed, and, though at first insignificant, they widened out year by year, until towards the end of last rainy season they had assumed such dimensions as to cause uneasiness. In a minute, dated the 3rd October 1894, His Honor Sir Charles Crosthwaite directed that a Committee, consisting of Lieutenant-

Colonel Corbett, R.E., Chief Engineer and Secretary to Government, Public Works Department, Irrigation Branch, Lieutenant-Colonel Pulford, R.E., then Officiating Chief Engineer and Secretary to Government, Buildings and Roads Branch, Public Works Department, and Mr. C. H. Holme, Executive Engineer, Public Works Department, should assemble to consider the question of the stability of Government House, and to say whether the limit had been reached beyond which it would be foolish to remain in occupation.

2. The Committee duly assembled, but one of the members, Mr. Holme, was unable to attend and did not serve on it at all. The report therefore represents the views of the other two members. It is necessary to remark, in passing, on the extraordinary delay which occurred in the submission of the report to Government. The first and only meeting of the two members of the Committee for the purpose of examining the house and site took place on the 18th October, but the report did not reach Government till the end of March 1895,—an interval of nearly six months from the date of the issue of the order convening the Committee. The great and apparently quite unnecessary delay in dealing with so important a matter is not satisfactorily explained by the Committee.

3. From observations made by the Committee and information supplied by the District Engineer, Naini Tal, it is stated in the report that an extensive series of cracks and fissures occurs in the rock immediately below the cap soil near the verandah at the billiard room end of the building, the fissures being some 9" wide and of considerable depth, and probably extending below the main corridor inside the house, where a well marked crack is seen, which has been in existence since the house was built. The levels furnished by the District Engineer would seem to indicate that the front portion of the plinth of the building has subsided from 7 to 10". That this settlement has been accompanied by "an outward movement of separation" is, the Committee consider, proved by the "steadily increasing widening which careful measurements show has taken place each year between the main wall of the drawing room and the outer wall of the conservatory." For these and other reasons specified in the report the Committee were of opinion that it would be advisable to vacate Government House during the rains of 1895.

4. In the concluding paragraph of the report the Committee drew attention to the very unsatisfactory state of the closed drains at Government House, and expressed the opinion that, owing to cracks in them, they were calculated to injuriously affect the stability of the site, and recommended that they should be put into order and made open for the future.

5. In his forwarding letter Colonel Corbett remarked that, although he held without reservation the opinions expressed in the report, he would be glad if the matter were considered by a larger Committee before action was taken on it. Bearing in mind that the question of the

safety of Government House is one of grave importance, not only to Government, but also to the whole community of Naini Tal, and more especially to house proprietors, it appeared to His Honor the Lieutenant-Governor and Chief Commissioner essentially necessary that the matter should be very fully enquired into and investigated by a strong Committee consisting of Engineers with local knowledge and including an experienced officer of the Geological Survey of India acquainted with Naini Tal. His Honor selected Mr. J. S. Beresford, Chief Engineer, Public Works Department, (whose services were placed at the disposal of this Government by the Chief Commissioner, Central Provinces) to act as President of the Committee. Mr. Beresford has an accurate and intimate knowledge of Naini Tal, acquired during an experience embracing a period of about twenty years, and has served on the Committees of 1880, 1882, and 1883, the two former having to do with the general question of the safety of Naini Tal and the measures necessary to prevent a repetition of the landslip of 1880, whilst the Committee of 1883 was appointed with the special object of enquiring into the stability of Government House, which was even at that time thought to be insecure. The Government of India was asked to depute Mr. R. D. Oldham, Deputy Superintendent, Geological Survey of India, to serve on the Committee. Mr. Oldham reported on the landslip of 1880, and in 1889 he again visited Naini Tal to report on certain matters connected with the stability of the hill slopes. In addition to his local knowledge Mr. Oldham has, it is understood, given special attention to the study of landslips, both in this country and in Switzerland. The other members of the Committee have all resided in Naini Tal for some time, and one—Lieutenant-Colonel Pulford, R.E.—has a very intimate acquaintance with it, extending over a considerable period. Mr. Beresford reached Naini Tal on the 11th April, but, owing to being engaged on other work, Mr. Oldham did not arrive till some days later.

6. The Committee made a most thorough and complete examination of Government House, its site, and the Sher-ka-danda hill generally. The various matters dealt with in the report were all [with, perhaps, the exception of No. (13) of paragraph 19, which, *vide* Mr. Oldham's note of the 13th May, was apparently not considered] discussed at full meetings of the Committee, and it is understood that all were unanimously agreed to before being embodied in the report. It is observed that the report is signed by all the members, with the exception of Mr. Oldham, whose reasons for not doing so will be referred to later on. The conclusion arrived at by the Committee is to the effect that they agree with the view expressed in the report of Colonels Corbett and Pulford that the present state of Government House is unsatisfactory, but that to admit this does not imply that the building is structurally unsafe or unfit for a residence (paragraph 18), and in paragraph 19 it is definitely stated that the Committee are of opinion that Government House is structurally safe and may continue to be occupied by His Honor the Lieutenant-Governor. In a previous paragraph (16) the Committee assert that, in their opinion, no immediate apprehension for the safety of Sher-ka-danda hill need be felt owing to the existence

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of the irregular crack described in the opening part of the paragraph. The reasons which the Committee adduce in support of their view that Government House can be safely occupied are given in considerable detail and, in the opinion of Government, they appear to be sound and deserving of acceptance. From what is said in paragraph 3 of the report, it seems impossible to come to any other conclusion than that arrived at by the Committee, *viz.*, that the building is structurally safe; nor can it be doubted that the defective drainage described in paragraph 4, in consequence of which large quantities of water have probably for many years past been soaking into the hill, affecting prejudicially the frictional stability of the material on which the foundations of the building rest, is, if not entirely, at least in a great measure, the cause of the subsidence which has unquestionably taken place. The extract given in paragraph 11 from a letter written by the Executive Engineer, Kumaun Division, in February 1879, shows conclusively that the importance of keeping the surface water from the foundations was fully recognised then, and is strongly confirmatory of the opinion expressed by the Committee that to faulty drainage the subsidence observed in the building may be largely ascribed. It is noticeable that the settlement of 6'84" indicated by the levels furnished by the District Engineer to Colonel Corbett's Committee is stated, in paragraph 3 of the second Committee's report, to be incorrect owing to the original slope of the verandah floor not having been taken into account, and that the actual sinking is not more than 2½". In the same paragraph it is asserted that the measurements given in paragraph 9 of the report of the first Committee "cannot be regarded as a true measure of any movement which has taken place within the main building." In paragraph 5 of Colonel Corbett's Committee report it is remarked that certain fissures in the rock near the building were found to be about 9" wide and of considerable depth. This looks alarming; but unless it can be shown that the fissures have widened since the building was constructed, the statement is of absolutely no importance whatever as affecting the stability of the house or of its site. There is no proof of any kind that the fissures referred to have increased since their existence was first known previous to the laying of the foundations of Government House.

7. On the 13th May Mr. Oldham wrote a note, which is attached to the report, stating that section 19 had not been fully discussed at the last meeting and that a recommendation [No. (13) of paragraph 19] had been added. The recommendation alluded to is in connection with the observations it was considered desirable to have taken in order to ascertain if there is any movement of the Sher-ka-danda hill. Mr. Oldham considered them inadequate, and that the results obtained from them would not be of much value. As the objection raised does not affect the stability of Government House or of the hill on which it is built, it is not necessary to further refer to it. On the 24th May Mr. Oldham wrote another note, in which he says that he concurs (in the report), with the exception of section 19, from which he dissents as a whole. He adds that a further examination of the hillside and

site has led him to consider that "the site of Government House, apart from any question of the stability of the structure, must already be regarded as unsafe during the rains." It would appear that, to be consistent, Mr. Oldham should also have dissented from paragraph 16 of the report, but his not having done so is possibly due to an omission. On the 3rd of June the report of the Committee reached Government, and on the 8th idem Mr. Oldham was addressed on the subject of his note of the 24th May, and asked to favour Government with a statement of the reasons which induced him to condemn the site of Government House, and for an expression of his opinion regarding the safety of the houses on the hill below Government House and of those on the same ridge. Mr. Oldham promptly replied on the 11th June. It is understood from his letter that the reasons which influence him in condemning Government House site are as follows: (1) the fissure extending from Government House to beyond Snow View, and the rapid development which has taken place in it since the examination made by him in 1889; (2) the "shearing" indicated by the numerous cracks noticeable in the masonry channel of the ravine between St. Loo and Staff House which was constructed in 1880; (3) the gaping fissures in the bare rock between the flag-staff at Government House and St. Loo grounds; (4) cracks in one of the walls of the dining room of Government House; (5) a movement of more than half an inch along a fissure which runs through the retaining wall and across the road under the flag-staff.

8. The opinion of Mr. Oldham is based on observations which must, of course, be convincing to his mind; and, coming from an officer of his knowledge and experience, it is necessary that it should be received with due attention and consideration. Seeing, however, that it is entirely at variance with the opinion expressed by the other members of the Committee, all of whom are fully qualified, both on account of their knowledge of the circumstances attending the case and of their training and experience as Engineers, to judge what is likely to happen, and having regard to the interests, not alone of Government, but also of the residents and house proprietors of Naini Tal as well as of those concerned in the continuance of Naini Tal as a summer resort, it appeared to His Honor most necessary that Mr. Oldham's condemnation of Government House site should be considered and tested on the spot by another experienced geologist, and the Government of India was accordingly applied to for the services of Mr. C. L. Griesbach, C.I.E., Director of the Geological Survey of India, for that purpose. Mr. Griesbach arrived at Naini Tal in due course and commenced his investigations immediately, and on the 30th June he reported to Government. It is seen from his letter that he fully agrees with Mr. Oldham that there is considerable danger of landslips occurring on the slopes of the Government House hill, and that the probability is they will occur there sooner or later; but in the absence of really conclusive data he states that it is impossible to say "whether such catastrophes may be looked for within a measurable time or not." He admits that there is some probability that a general movement along the south-west

face of the Sher-ka-danda hill does exist, but he considers that it is extremely difficult to prove. He is not satisfied that "the shearing in the drainage channels has anything to do with such a movement if it exists at all." "It may well," he adds, "be connected with ordinary earth pressure in the same manner as the various cracks in retaining walls or revetments along roads and behind houses": and he questions "whether they can be interpreted to be indications of the general movement hinted at." In paragraph 5 of the letter it is recommended that the suggestions of the Committee (Mr. Beresford's) be accepted and carried out. It may therefore be inferred from the above remarks that Mr. Griesbach does not consider the danger of a landslip on Government House hill to be imminent; that he is not of opinion that Government House must already be regarded as unsafe during the rains; and that he is doubtful of there being sufficient or satisfactory proof that there is a general downward movement of the hill at all. In regard to the first of Mr. Oldham's reasons, it is necessary to mention that he does not appear to have made any measurements of the crack at the summit of the hill either in 1880, when it is understood he first saw it, in 1889, or recently, and the only evidence that it has increased at all is his impression to that effect. Mr. Beresford, in paragraph 3 of his note of the 21st June, refers to this crack as having been in "existence for at least fifteen years, perhaps much longer," and states "that the width is probably nowhere over 2" when properly measured." The deliberate opinion of the Committee in regard to the crack is given in paragraph 16 of the report, reference to which has been made in paragraph 6 of this Resolution. Mr. Oldham may, of course, be perfectly right in his statement that there has been a rapid development of the fissure since 1889, but, in the absence of measurements, it is not possible to accept it as conclusive. Mr. Griesbach is not satisfied that the cracks in the ravines, which, Mr. Oldham states, indicate shearing, are due to the cause assigned, *viz.*, that they are the result of a general movement of the hill, but thinks that they may be connected with ordinary earth pressure. The gaping fissures between the flag-staff of Government House and St. Loo have, it is understood, been in existence for many years, and there is absolutely no evidence that they are wider now than at any previous time. It does not seem necessary to say more regarding the fourth and fifth reasons given by Mr. Oldham than that there is nothing whatever to show that they indicate a general movement of the hill. They are in themselves of a trivial nature and may readily be accounted for by local causes.

9. His Honor the Lieutenant-Governor and Chief Commissioner, whilst fully recognising that Mr. Oldham's opinion is an honest expression of the views entertained by him, and that it has not been given without careful thought and deliberate consideration, is, in the face of the confident opinion recorded by Mr. Beresford's Committee, supported as it is for all practical purposes by Mr. Griesbach's reassuring letter of the 30th June, unable to accept the statement that a landslip on the Sher-ka-danda hill endangering the safety of Government House site

is imminent. At the same time His Honor considers that owing in a great measure to the disgraceful condition into which the drains at Government House were allowed to fall, there has been cause for uneasiness, and it may be that the stability of Government House site has been to some extent injuriously affected by the large quantities of water which have poured into the interior of the hill for years past, in consequence of the neglect of the local Public Works Department officers responsible for the efficient maintenance of the drains. It may conveniently be noted here that all the drains at Government House site were carefully remodelled before the commencement of the present rains, and that the drainage is now all that can be desired. The experience of the landslip of 1880 goes to prove that ample warning of an impending landslip is given by unmistakeable surface indications, and it is satisfactory to be able to assure all concerned that a close scrutiny of the hill carried out by experienced and responsible officers has failed to bring to notice any signs whatever that danger of the kind is imminent.

10. A careful detailed examination has recently been made of the Sher-ka-danda hill, and the results show that it is now in a far sounder condition than that described in the report of the Committee of 1880. It has been found, however, that the works on the drainage lines carried out by Mr. Willcocks, have been permitted to fall into some disrepair owing to the indifference and neglect of the municipal authorities, but they were originally constructed in so solid a manner that the injury caused can readily be remedied. But even in their present state they efficiently answer the purposes for which they were built. The danger of landslips occurring from the cutting away of the sides of the ravines by the drainage water, to which the landslip of 1880 was mainly, if not entirely, attributable, is now practically non-existent along all the main ravines, owing to the excellence of the works carried out on the recommendation of the Committee of 1880; and it is not too much to say that if the other measures insisted on by that Committee as being necessary for the preservation of the hill slopes,—such as the construction of masonry channels along other drainage lines, the building of retaining walls where necessary, the prohibition of gardens and tennis courts at places considered to require careful treatment, and other precautions designed with the object of carrying off the rainfall as rapidly as possible and preventing it from soaking into the hill,—had been carefully attended to, there would in all probability have been no occasion for the uneasiness regarding the safety of the Sher-ka-danda hill which has recently been felt. The question of what requires to be done to act up to the recommendations made by the Committee of 1880, and the agency through which the necessary works and other measures, including the efficient maintenance of works previously constructed, are to be carried out, is being considered by Government in the Municipal Department, and orders on it will issue immediately.

11. The recommendations enumerated in paragraph 19 of the report of Mr. Beresford's Committee have all been or are being given effect to, and the information which will be afforded by the observations referred to in parts (6), (7), (8), (9), (13), and (14) of that

paragraph will before long admit of a definite conclusion being arrived at as to whether or not there is any movement going on of Government House hill such as to endanger the safety of the houses on it. Early in last year it was decided by Sir Charles Crosthwaite to have a complete and careful examination made of all the hill slopes of Naini Tal by an officer of the Geological Department assisted by officers of the Public Works Department. To admit of the examination being thorough and complete, it was necessary to prepare an accurate map of Naini Tal with certain contour lines plotted on it. The map is now nearly ready and arrangements have been made for the examination of the hill slopes referred to being commenced immediately after the end of the present rainy season. It is desirable to add that a capable and energetic officer of the Public Works Department has been placed in special charge of the duty of putting into efficient order the drainage works carried out in 1880-81, and of giving effect to the recommendations of Mr. Beresford's Committee. Every possible precaution has therefore been taken to ascertain the actual condition of the hill and to ensure that the measures which are thought necessary to carry off the drainage as rapidly as possible, and so prevent the waterlogging of the hill, are undertaken and completed without delay.

ORDER.—Ordered that copies of this Resolution be forwarded to the Secretary to Government, Municipal Department, and to the Commissioner, Kumaun Division, for information.

Also that a copy be sent to the Superintending Engineer, 2nd Circle, Public Works Department, for information and guidance, with a copy of the report of Mr. Beresford's Committee.

Ordered, also, that a copy be published in the *North-Western Provinces and Oudh Government Gazette*.

By order, &c.,

J. G. H. GLASS,

*Secy. to Govt., N.-W. P. and Oudh.
P. W. Dept., B. and R. Branch.*

PART II.

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File No. 44B.]

No. $\frac{2021}{XVIII-31}$, dated the 1st February 1895.

From—COLONEL F. E. GRIGG, *Offg. Commissioner, Kumaun Division,*

To—Secretary to Government, N.-W. P. and Oudh, P. W. Dept.,

B. and R. Branch.

SIR,—I have the honor to submit copy of a letter No. $\frac{1378}{M. G.}$, dated 26th January 1895, from the President, Municipal Committee, Naini Tal, reporting the instability of part of the lake side of the Sher-ka-danda hill at Naini Tal, and to solicit that the proposal made by the President may be given effect to.

No. $\frac{1378}{M. G.}$, dated the 26th January 1895.

From—F. GILES, Esq., *President, Municipal Committee, Naini Tal,*

To—Commissioner, Kumaun Division.

SIR,—I have the honor to report that Messrs. Matthews, Banyard, Wildeblood, Oertel, Orchard, and I have gone over the hillside between the Grand Hotel, the Allahabad Bank premises, and Ravenswood at Naini Tal. There were cracks in the retaining walls behind the Grand Hotel, and the Bank premises were settling in all directions. The entire hillside appeared to be in a more or less unstable condition.

Mr. Banyard suggested that the slope should be drained by running tunnels inwards from their surfaces. The Engineers, however, without a detailed study of the ground, were not agreed that this measure is likely to be effectual. But they were of opinion that the condition of the hill is such as to demand thorough examination. It is understood that a Committee of experts lately considered the state of the Sher-ka-danda hill with special reference to the safety of Government House. It will relieve the Municipal Committee from a responsibility to which they are unequal if Government is pleased to permit a member or members of this Committee to advise them as to what steps, if any, are necessary to ensure the stability of the lower slopes of Sher-ka-danda and the buildings bordering the lake between the landslip and Tali Tal bridge.

No. $\frac{851W.A.}{2131}$, dated Allahabad, the 12th February 1895.

From—J. G. H. GLASS, Esq., C.I.E., *Chief Engineer, N.-W. P. and Oudh,*

P. W. Dept., B. and R. Branch,

To—Superintending Engineer, 2nd Circle, Provincial Works, N.-W. P. and Oudh.

SIR,—In forwarding copy of the correspondence marginally noted, I have the honor to request that you will take immediate steps to make a careful and complete examination of the locality described in the letter from the President, Municipal Committee, Naini Tal, and submit a report of your inspection for the information of Government at as early a date as possible. You should show what, in your opinion, are the causes which have led to the cracks

Letter from Commissioner, Kumaun, No. $\frac{2021}{XIII-31}$, dated 1st February 1895, and enclosures.

in the retaining walls behind the Grand Hotel: *i.e.*, whether they are due to the walls being badly designed or to a movement of the hillside, and how you account for the settlements in the Allahabad Bank premises. You should also say what remedial measures are possible should your inspection lead you to the conclusion that the cracks and settlements are the result of a general movement of the hillside. The matter is one of first importance and requires to be promptly dealt with.

2. The Executive Engineer, Kumaun Division, should be instructed to place himself in communication with the President, Municipal Committee, Naini Tal, with the object of affording the Committee such advice and assistance as it is in his power to render.

No. $\frac{1211W.A.}{2131}$, dated Allahabad, the 28th February 1895.

From—J. R. C. NICOLLS, Esq., *Under-Secretary to Government,*
N.-W. P. and Oudh, P. W. Dept., B. and R. Branch,
To—*Commissioner, Kumaun Division.*

ORDERED that copy of the foregoing be forwarded for information with reference to the Commissioner's No. $\frac{2021}{XVIII-31}$ dated the 1st February 1895.

No. $\frac{1287L}{77}$, dated Lucknow, the 21st March 1895.

From—LIEUT.-COLONEL R. R. PULFORD, R.E., *Superintending Engineer,*
2nd Circle, Provincial Works, N.-W. P. and Oudh,
To—*Chief Engineer, N.-W. P. and Oudh, P. W. Dept., B. and R. Branch.*

SIR,—With reference to your letter No. $\frac{861W.A.}{2131}$, dated 12th February 1895, regarding the alleged dangerous state of the Sher-ka-danda hill at Naini Tal, I have the honor to report that, in accordance with your instructions contained in that letter, I made a thorough inspection of the hillside on the 16th February 1895. The following is the result of my inspection.

The chief point to be investigated was the stability of the hillside immediately in the vicinity of the Allahabad Bank, the Grand Hotel, and the house known as "Ravenswood." Dealing with them in their order, I give the following opinions.

Allahabad Bank.—The cause of the cracks and settlement of the walls in this house is undoubtedly the faulty construction of the foundations at the back of the house. These had not been founded upon a sufficiently firm stratum: nor had any provision been made for carrying off the water from a spring which issues from the hillside at this point. The result has been that this water has soaked into the stratum below the foundations of the back walls and has caused marked settlement over a considerable area. Measures for remedying this state of affairs were already in progress when I visited the spot. A concrete lined masonry drain had been built to carry off the spring water clear of the foundations, and these latter were being properly underpinned and strengthened. So far as I can judge, the remedies applied to the Bank premises should give highly satisfactory results.

The Grand Hotel.—I inspected the whole of this building and all the back walls and drains connected with it. I confess that I was quite unable to notice any of the alarming symptoms mentioned by the President of the Naini Tal Municipality in his letter of the 26th January 1895, to the Commissioner of Kumaun. In my opinion, the hillside behind the Grand Hotel is so far in a satisfactory condition, and the state of the retaining walls is not such as to indicate any

want of stability in the ground supported by them. They have evidently been well designed and well built. So far as I could see, they are as sound now as ever they were, and there is no cause for present anxiety in regard to their safety.

"Ravenswood." — I inspected this site thoroughly some ten years ago at the request of the Naini Tal Municipality. On the present occasion I again went carefully over the ground. The front portion of the site has sunk slightly, and there are signs of subsidence close to the house. The retaining wall, though slightly bulged, does not, however, appear to have been forced forward, and I think that in this case, as in several others which I have noticed, the subsidence is due to slight settlement of that portion of the site which is formed of the material excavated from the hillside when the site was first prepared. In such cases the practice is to cut out a certain portion of the hillside and to throw out the excavated stuff so as to increase the width of the plateau on which to build. The made soil thus used as a portion of a building site is, as a rule, supported by a dry rubble retaining wall, and if this is not designed fully strong enough, there is always liability of the made portion of the platform site showing signs of subsidence. This, I think, has been the case with the Ravenswood site,—an opinion, if I remember rightly, which I formed and expressed when I inspected the place ten years ago.

From the above remarks it will be seen that I do not attach importance to the opinion put forward in the letter of the President of the Naini Tal Municipal Committee of the 26th January 1895 in regard to the instability of the hillside.

With reference to the second portion of the Municipal President's letter, *viz.*, as to what steps, if any, are necessary to ensure the stability of the lower slopes of the Sher-ka-danda, I have to make the following remarks.

The attention of the Municipal Committee should be drawn to the provisions and recommendations of the Committee appointed by Government Resolution No. ^{C532}₅₃₇, of 22nd September 1880, in September 1880, to enquire into the condition of the Sher-ka-danda hill. Paragraph 12 of that Committee's report should be specially brought to the Municipality's notice, and it would be well if they were called upon for a specific and detailed report as to how far the provisions contained in that portion of the Committee's report have been observed. For facility of reference I give (*vide annexure*) *in extenso* the paragraphs in question. There are several watercourses to the east of "Ravenswood," notably the one next to that site, which should be taken in hand at once, and the surface drainage of all platforms should be carefully overhauled. I noticed particularly under this last head that the outer portion of the new tennis court at St. Loo has sunk very considerably, and excavations at the site of the crack showed that the fissure extended far below the surface.

The cause is probably that already referred to when discussing the subsidence observed in the "Ravenswood" platform. The line of subsidence is probably that of the junction of the made soil taken from the hillside with the solid platform cut in the hill itself.

I further think that it would be well if the entire system of protective works carried out in 1880-81 were carefully gone over and thoroughly inspected, in view to seeing what, if any, repairs or additions have become necessary since the date of their construction fourteen years ago. There can be no doubt that the nature of the Sher-ka-danda hillside is such as to require constant supervision and careful treatment if serious slips are to be avoided and its stability assured.

Extract paragraph 12 of letter No. C.611B.R., dated Naini Tal, the 11th October 1880, from COLONEL BROWNLOW, R.E., Secretary to Government, North-Western Provinces and Oudh, Public Works Department, to the Secretary to Government, North-Western Provinces and Oudh, General Department.

12. The following measures are, in the opinion of the Committee, absolutely necessary to prevent further damage, and to protect the station from danger in the future :—

Remedial measures.

- (1) All important ravines (see paragraph 19) should be revetted at intervals by strong cross walls curved in plan, with well guarded flanks (or wing walls) built into the rock on either side. These walls should have considerable batter on the face, the courses being laid at right angles to the batter.
- (2) All ravines should be lined where necessary with side walls and strongly paved flooring laid in lime mortar, the channels being made large enough to carry at least double the maximum flood volume which has been known to flow down them up to date.
- (3) The cracks and fissures in the hillside should be carefully searched for, dug out as far as they can be traced, and refilled with well rammed clay.
- (4) The platforms round every house within the limits specified in paragraph 5 (or wherever the Civil Officer in charge of the station thinks necessary) should be covered with a six-inch layer of well rammed clay, or other material impervious to water. (When houses have been destroyed and abandoned this might be done at the expense of the public and not at that of the proprietor.)
- (5) Gardens and cultivated terraces should be absolutely prohibited. Those that exist should be covered with clay and turf immediately, and existing lawn tennis grounds should only be permitted to remain on condition that similar precautions are taken to prevent the percolation of water into the hillside.
- (6) The further erection of houses or other buildings, quarrying of stone, and the excavation of terraces or platforms for any purposes whatever should be absolutely prohibited in the southern slope of the Sher-ka-danda hill within the limits specified in paragraph 5.
- (7) Special care should be taken to prevent injury from house drainage. Every house should have a gutter under the eaves and a catchwater drain round its base. The water from these should be carried in a masonry channel to the most suitable ravine in which provision should be made for its reception.
- (8) House proprietors should be compelled to restore in an efficient manner all retaining walls which are bulged or cracked; and, further, to build such walls where they do not exist and where their absence has caused or may hereafter cause slips in the hill above; also where there is any tendency to slip, to slope off the hill immediately above all retaining walls to an angle of 40°. This order should be binding on all proprietors, whether the houses or their estates are occupied by tenants or not.
- (9) The Civil Officer in charge of the station should be responsible for the maintenance in proper order of all watercourses in ravines and of all roadside drains. Special gangs should be employed during the rains to keep the drains free from obstruction and to repair damage immediately it occurs.
- (10) An honest, efficient, and trustworthy subordinate should be appointed as Inspector of buildings and drains, who should be under the sole orders of, and responsible only to, the Civil Officer in charge of the station.

(11) All the arrangements for drainage of houses, roads, and property and the building of all revetment walls, and in short all operations which affect the safety of the station, should be carried out by order of the Civil Officer in charge, through the agency of this Inspector. Where these necessary improvements are executed on private property, the house or land owner should be made to pay the cost. Private individuals should not be allowed to construct any drains, walls, or buildings without the written permission of the Civil Officer and the supervision of the Inspector.

(12) All steep slopes should be turfed and planted. Grass-cutting and grazing on the southern slopes of "Sher-ka-danda" and "Cheena" should be strictly prohibited.

(13) The Civil Officer should have power to carry out the above and other measures for the safety of the station without reference to the Municipal Committee.

(14) And, finally, whatever sums are set aside by Government or the Municipality for the maintenance and improvements of drains and roads should be at the disposal of the Civil Officer, to be expended by him without reference to the Municipality in a regular and systematic plan, with the advice, when necessary, of the Superintending Engineer of the Provincial Circle.

No. 2491W.A., dated Naini Tal, the 13th April 1895.

From—J. G. H. GLASS, Esq., C.I.E., Secy. to Govt., N.-W. P. and Oudh,
P. W. Dept., B. and R. Branch,
To—Commissioner, Kumaun Division.

SIR,—With reference to your letter No. ²⁰²¹~~XVIII-31~~, dated 1st February 1895, on the subject of the condition of Sher-ka-danda hill, I am directed to forward the accompanying copy of a letter No. ^{1287L}~~77~~, dated the 21st March 1895, and enclosure, from the Superintending Engineer, 2nd Circle, Provincial Works, and to request that you will be so good as to communicate the contents thereof to the Municipal Committee, Naini Tal, and invite the special attention of that body to the rules framed by the Committee of 1880 which was appointed to enquire into the condition of Sher-ka-danda hill and to report on the measures which should be adopted to prevent slipping of the hill. I am to specially invite attention to paragraph 12 of that report, and to ask that you will be good enough to state if the provisions therein contained have been strictly observed.

No. 3583W.A., dated Naini Tal, the 1st June 1895.

Copy forwarded to the Superintending Engineer, 2nd Circle, Provincial Works, North-Western Provinces and Oudh, for information.

By order, &c.,
J. R. C. NICOLLS,
Under-Secy. to Govt., N.-W. P. and Oudh,
P. W. Dept., B. and R. Branch.

No. ^{3581W.A.}~~2131~~, dated Naini Tal, the 1st June 1895.

From—J. G. H. GLASS, Esq., C.I.E., Secy. to Govt., N.-W. P. and Oudh,
P. W. Dept., B. and R. Branch,
To—Commissioner, Kumaun Division.

SIR,—In continuation of this office No. 2491W.A., dated 13th April 1895, I am directed to inform you that the Superintending Engineer, 2nd Circle, has been instructed to depute Mr. H. S. Willdeblood to examine the Sher-ka-danda hill at Naini Tal, with a view to ascertaining how far the recommendations of the Committee of 1880 are being given effect to, and suggesting any alterations or improvements that may appear necessary.

No. 3582W.A.

COPY forwarded to the Superintending Engineer, 2nd Circle, Provincial Works, North-Western Provinces and Oudh, for information and necessary action.

By order, &c.,

J. R. C. NICOLLS,

Under-Secy. to Govt., N.-W. P. and Oudh,

P. W. D., B. and R. Branch.

No. $\frac{4465}{XVIII-31}$, dated the 1st June 1895.

From—COLONEL E. E. GRIGG, *Offg. Commissioner, Kumaun Division,*

To—Secretary to Government, N.-W. Provinces and Oudh,

P. W. Dept., B. and R. Branch.

SIR,—In reply to G. O. No. 2491W.A., dated 13th April 1895, I have the honor to submit copy of a letter No. 258, dated 28th May 1895, from the President, Municipal Committee, Naini Tal, and its enclosures in original (*the return of which is requested*), regarding the instability of the lower slopes of the Sher-ka-danda hill.

No. 258, dated Naini Tal, the 28th May 1895.

From—C. H. ROBERTS, Esq., *President, Municipal Committee, Naini Tal,*

To—Commissioner, Kumaun Division.

SIR,—In reply to your endorsing order No. $\frac{3533}{XVIII-31}$, dated 24th April last, forwarding copy of Government Order, Public Works Department, No. 2491W.A., dated 13th April 1895, giving cover to letter No. $\frac{12871}{77}$, dated 21st March 1895, from Superintending Engineer, 2nd Circle, Provincial Works, regarding the stability of the lower slopes of the Sher-ka-danda hill, I have the honor to submit the following report. The remedies proposed by the Superintending Engineer are those recommended by the Committee of Engineers which assembled after the landslip of 1880, and are given in paragraph 12 of letter C.611B.R., dated Naini Tal, the 11th October 1880. I will take up each recommendation *seriatim*. I may premise my remarks by stating that I thought the best way to secure evidence from the house owner's point of view was to call on Mr. Matthews, house agent, to state his views. That he has done at some length, and his statement may be valuable to the Committee of Engineers now considering matters pertaining to the stability of Government House and Sher-ka-danda hill. Regarding remedial measures proposed by Committee of 1880—

(1), (2), (3). The work done after the year of the landslip, representing roughly
 (1) Retement of drains, two lakhs of rupees, shows the protective works undertaken under this head. As the Committee had to meet interest and sinking fund of this loan to the amount of Rs. 1,21,793-9-7, being an annual contribution of Rs. 5,000 per annum with interest on Rs. 1,50,000, they may fairly lay claim to have done their share of the protective

	Rs.	a.	p.	
1880-81 ...	1,13,725	11	3	measures. The statement in the margin shows money spent
1881-82 ...	97,854	10	0	in annual repairs and works which may be fairly called protective.
1882-83 ...	11,792	5	1	From this you will see the Committee have—at any
1883-84 ...	4,900	0	9	rate up to end of 1892—spent fairly large sums on protective
1884-85 ...	1,883	13	3	measures, and it must always be remembered that the encum-
1885-86 ...	5,282	13	8	bered state of municipal funds consequent on having to meet
1886-87 ...	804	2	10	the landslip loan rendered them unable to go in for any fur-
1887-88 ...	865	13	8	ther expensive original protective works, nor were they able
1888-89 ...	1,303	12	2	to extend the works done in 1881-82 under Mr. Willcocks.
1889-90 ...	1,484	0	7	
1890-91 ...	4,066	4	0	
1891-92 ...	8,943	11	6	
1892-93 ...	765	9	6	
1893-94 ...	<i>Nil.</i>			
1894-95 ...	290	8	9	
Total ...	2,48,929	4	2	

The Committee could only work tentatively with the limited funds at their disposal as occasion demanded.

After 1892-93 a new era was started; the landslip loan being remitted, the Committee were forced into very large capital expenditure in order to get the place under better sanitary regulations.

Expensive sewer works were constructed and a potable water supply scheme was undertaken; slaughter houses and coolie lines were also built. There was bad cholera in 1888, 1890, and the cry of freedom from disease seemed to overpower the 1880 cry of safety from land avalanche. A large loan of Rs. 2,60,000 was raised to construct the abovementioned works, and a glance at the Naini Tal Municipal budget will show that our financial means to continue a system of protective works is narrowly circumscribed. A limit has been reached from the tax payer's point of view. We cannot increase the tax incidence, and we can only cut our coats according to our cloth and do the best we can with the limited funds at our disposal. The Committee are in no wise to blame for the present state of matters.

As nominees of Government and well understanding that the well-being of Naini Tal depends on it being the hot weather capital of the North-Western Provinces Government, the Committee have spent funds in such ways as best would meet the wishes of the Government of the day, and they have even let Government supply the agency to construct works on estimates drawn up by departmental engineers. In order to make expenditure balance with income, the Committee had to cut down by some thousands their works expenditure.

Though much remains to be done to better protect the hillside, the Committee are financially unable to do it.

(4) and (5). I agree with Mr. Matthews that these measures suggested were not carried out. I think some attempts were made in the early eighties, but hostile house owners and a constant change of executive caused matters to be dropped.

(4) Covering platforms with clay.

(5) Absolute prohibition of gardens and maintenance of all tennis courts on condition of being covered with clay.

(6). There has been care exercised by the Municipal Committee in this matter.

Before new houses, &c., are erected the locality is carefully examined and reported on by the sub-committee. But certain departures have been made within my memory; the

(6) The further erection of houses, &c., within the limits specified.

Government House gardens in St. Loo were made entirely without prior intimation to the Municipal Committee. The Superintending Engineer, in his letter under reference, comments on the cracks observable on this side. Mr. Matthews draws attention to them, and they are within the area considered unsafe by the 1880, 1882 Engineer Committees. The expert Committee condemned certain sites and ordered them to be dismantled, e.g., Maldon estate over the 1880 landslip, Dudley Grove, and, I believe, the Rappur site above the Albion. The Municipal Committee have permitted building on all these sites. Here, however, the Committee have acted only under professional advice; in all instances they have declined to sanction the building on these sites unless supported by experts' opinion that the site was a safe one. This has, it is believed, in all instances been obtained, the opinion given being that a well drained house is better than a badly drained site.

(7). Some activity was shown in this matter after the landslip and a bye law was passed in 1881, section 3, page 27, rule 22, and (energy,

(7) Conducting house drainage to the most suitable ravine. however, being somewhat relaxed owing to change of officers)

I do not think enough was done to secure the house drainage being put in proper order. Defective gutter piping was put up; drain pipes were allowed to get choked with leaves, &c. Further gutter piping came away with snowfall and was not replaced. The house lessees who could help the Committee

in the matter by furnishing information are apathetic. I think, however, a little more activity on the part of the Committee at the commencement of the season might lead to better results.

(8). This received attention in the years immediately following the 1880 landslip, and as occasion demanded the provisions of the bye-laws have been worked to compel owners to take proper order with their property.

(8) Restoration of retaining walls by proprietors sloping off the hill above.

(9). The Civil Officers as President and Vice-President of the Municipal Committee have given these matters their attention. Special gangs of labourers are kept up and are moved from place to place as occasion demands.

(9) Civil Officers to be responsible for maintenance of all drains.

(10) and (11). The Municipal Committee have for the last four years engaged the services of a Secretary and Engineer with Public Works Department training. He is responsible to the Committee and the President for all drainage works.

(10) Efficient and trustworthy subordinates to look after drains, &c., under orders of court officer.

(11). Since 1880 there has been a very frequent change of Civil Officers, but in all difficulties the officer of the day has consulted Engineer

(11) All operations affecting safety of Naini Tal to be under Civil Officer.

experts in matters cropping up connected with safety and drainage. I doubt if more continuity of action could have been made with the limited funds at the Committee's disposal. Private owners are not allowed to construct any drains, walls, or buildings without the written permission of the Municipal Committee; great attention has been paid to this.

(12). The only place where turfing and planting has been done to any great

extent is on the face of the 1880 landslip and on the slip of 1888 over the Hindu temple. I do not myself know any other part of the station where it could well be undertaken; it is hard to plant on bare rock. The rules against grazing on Sher-ka-danda and Cheena are given in the bye-laws, section 3-10 (a) and (b), page 25, and have been enforced. Cattle owners, however, are constantly offending the rule by grazing cattle in their house compounds. There have been frequent prosecutions under the rules.

(13) and (14). There is an attempt here to substitute a rigorous personal

(13) Civil Officers to have power to carry out measures without reference to Municipal Committee.

(14) Civil Officer to have sole control of funds without reference to the Municipality. The advice of Superintending Engineer, Provincial Circle, to be obtained when necessary.

executive for government by corporation, but when Government re-appointed the Municipal Committee after the 1880 landslip, when the then members resigned, they must have duly considered these points. When, owing, to change of officers, continuity of management cannot be had, I do not think government by committee a bad substitute. The Civil Officers have always a body ripe in local knowledge to appeal to. Further, as regards the construction of works undertaken, he has always the engineering staff of the North-Western Provinces and Oudh Government to consult in professional details. A new man would be more at sea without his committee than he now is with them to consult in local matters.

The only fault with the Committee is that all the non-official members are house property owners, and they are inclined to vote for each other to thwart the President when any remedial measure is proposed likely to touch the pocket of a house owner. When any point has been disposed of by one officer and the particular matter is distasteful to them it is brought up again in a slightly modified form as soon as that Civil Officer has left the station.

Regarding the existing state of the hillsides and cracks noticed by Mr. Matthews, I commend his reports to the consideration of the Committee of Engineers now investigating the state of Naini Tal.

Dated Naini Tal, the 1st May 1895.

From—F. E. G. MATTHEWS, Esq., *Naini Tal*,

To—President, *Municipal Committee, Naini Tal*.

SIR,—The Secretary to the Municipal Committee has sent me for perusal copy of Government Order, Public Works Department, No. 2491W.A., dated 13th April 1895, Buildings and Roads Branch, to the Commissioner of the Kumaun Division, on the margin of which you have been good enough to refer to my services on the Committee, and to ask for suggestions from me.

2. The letter from Government gives extracts from a letter No. C.611B.R., dated Naini Tal, 11th October 1880, from Colonel Brownlow, R.E., Secretary to Government, North-Western Provinces and Oudh, Public Works Department, to the Secretary to Government, North-Western Provinces and Oudh, General Department. I take the remedial measures Nos. 1 to 14 *seriatim*, placing them on the left margin of a sheet, and on the right I have given what information I possess as to how far the instructions as to remedial measures were carried out.

3. Colonel Brownlow did me the honor of inviting me to attend the Committee (of which he was the Chief, in September 1880) when inspecting the various localities affected on Sher-ka-danda, and I was invited to send in a written report, which I did some time before end of September 1880.

4. Circumstances induced me to get it printed in 1888, and all the copies having been absorbed by people who were curious to read it, I had a fresh edition published in 1892. I send three copies in the hope that they may be useful, and can send more if needed. The first five pages of preface may be eliminated as of no present use. My report of 1880 is comprised in pages 1 to 18. The pages that follow had also better be eliminated. I have read my report carefully over; it gives dates of erection of all the houses affected, and shows to what extent they were affected, and I do not, after a lapse of fourteen years, find many parts that I would like to have written differently.

5. I would draw your attention to page 11, where I describe the appearance in 1879 of a new stream in the Edge Hill. Mr. Willcocks lined this ravine, from Mall above Edge Hill downwards. For some reason he did not use lime in the middle portion of the masonry. A large volume of water may be observed appearing at the source of the spring, and, unless in very heavy rain, not a drop passes the Mission premises. I brought this to notice more than once, and I think it is essential to attend to.

6. I have been observing three settlements, which began in 1880 and have gone on, slowly increasing, yearly since. I attach a tracing from the map of Naini Tal showing the position of each, and I call them A, B, and C. They all appear to have connection with each other, and as the last one is on the Mall, over the head of the Edge Hill ravine, I think the ravine should be examined from the Mall to the Mission premises. A few yards to the west another ravine descends from the Mall and the two become one above the Mission premises. The spring of water is in the most westerly of the two branches.

I would draw attention to page 14 of my report, paragraph 7. The discharge of the roadside drain in September 1880 set in motion that part of Spring Hall (Phoenix Lodge) estate which lies immediately to east of the ravine. Mr. Willcocks knew this, and arranged that no flood water should be allowed to run in this ravine from the upper block of outhouses. He took off the water there, and conducted it into the Ravenswood ravine by a masonry channel. This is very badly cracked now. A wooden trough took this water up to 1880, *vide* page 13 of my report, paragraph 5. The owner of Phoenix Lodge arrested any water which came

down this ravine, at his cook house, and carried it behind the house to the Ravenswood ravine, so that very little gets down the lowest part of ravine. Notwithstanding these precautions, the movement of the western part of Phoenix Lodge terrace has never entirely ceased, and it became more pronounced than usual last year. The Municipality have given the owner orders to put clay all over the garden. This would not arrest the movement which began in 1880. I went over the estate with Mr. McClay a short time back, and I told him what I thought should be done. I am at your service if you wish me to go to the spot. If it will be borne in mind that houses on the east bank of every ravine on Sher-ka-danda, even though situated at an apparently safe distance from it, will, once the cap soil moves, slip, and continue to slip, to west, it will be easily understood what is going on at Phoenix Lodge. On the west bank of every ravine houses stand safely perched on the very edge of the ravine, because the strata of shale run from east to west. Instances of this may be found in Phoenix Lodge itself, which is close on the edge of the Ravenswood (or Rájpur) ravine; also St. Helens, which appears dangerously near the Club ravine, but has never suffered. Alma Cottage is another house which looks to be in dangerous proximity to the Rosamond ravine, but is not affected by it; whilst Snow View, St. Cloud, Brae House, and Brae Side, all situated a long way on east bank from the ravine, indicate, by their cracks, which way the movement is, *viz.*, to west.

I learnt to observe this from Colonel Brownlow's remarks, whenever I met him, in September 1880, and, in the first paragraph of my report, page 1, I note this.

The Phoenix Lodge movement may go on for an indefinite period without a great smash. It has not developed much in twelve years. (Phoenix Lodge was built on the site of Spring Hall in 1882.) But, on the other hand, a large slip may be brought down during any very heavy rain. If unattended to, a great smash is inevitable here, sooner or later, and it ought to be attended to.

Review of the orders of Government, dated 11th October 1880, and of what was done to carry them out.

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Mr. Willcocks carried out this work in a very able manner. His money (and time) being limited, he attended to the ravines in the order of their importance, and he watched their working throughout the year 1881. Then he had to leave. He expected (*A*) that his work would be kept in repair; (*B*) that many minor ravines would be taken in hand year by year; and (*C*) that the upper ends of his masonry lined ravines should, as occasion demanded, be prolonged upwards.

- (1) Revetment of drains
and
(2) The same subject.

(*A*) Repairs have been (more or less) attended to. Representing, as I do, about one-third of the houses for renting to visitors in Naini Tal, I made it my business to watch the ravine masonry throughout each rainy season. Mr. Willcocks used a good deal of wood, placed at intervals across these drains. In many places the wood has decayed and disappeared, but I have not noticed that the masonry had suffered much except in the drain which carries the flood water of "Sleepy Hollow," past "Langdale," into the lake, and here the paving was a good deal torn up in consequence

Constructed by Major of the disappearance of the wood.
Garstin. I am not at all certain that Mr.
Willcocks constructed this particular drain. There

REMEDIAL MEASURES.

was an understanding between Major Garstin and Mr. Willcocks that Major Garstin would carry out all works on Ayarpata, which was a comparatively unimportant locality and Mr. Willcocks would attend to "Sher-ka-danda." I am absolutely positive that the "Endclyffe" drain was constructed by Major Garstin, but I am not so positive as to the "Langdale" drain. Mr. Willcocks invariably carried water over steep slopes by stepped flooring—what he called water ladders. This stepped flooring does not exist in some very steep parts of the "Langdale" drain.

(B) Very few minor ravines have been attended to since Mr. Willcocks left Naini Tal. A great many exist between his most eastern work, the "Rolaston" ravine, and the extreme end of "Sher-ka-danda." These have widened and deepened considerably since 1881, but the formation is pretty firm shale, and it cuts away slowly.

Mr. Hodges put in some masonry at a place above "Rolaston," where a mass of soil began to move in 1890. But a good deal of attention is needed to the minor ravines to east of "Rolaston." To describe each spot would occupy pages; a walk over the ground would be more satisfactory.

(C) I cannot call to mind that any of Mr. Willcocks' drains have been produced upwards. Some of them may need being produced. But I again would suggest that an examination of them would be advantageous, and I will make time, if desired, to accompany the Committee.

(3) Filling of cracks and fissures.

This was done, and I can point out some of the most important ones.

Colonel Anderson had a map prepared of Naini Tal showing the exact position of all cracks. I have never been able to see it during the past fourteen years, and I do not know where it is, if not with the papers left by Mr. Willcocks in the office.

(4) Covering platform with clay; and

I think that (4) and (5) were generally ignored. Mr. Willcocks was absorbed in getting the ravines lined with masonry.

(5) Absolute prohibition of gardens and maintenance of all tennis courts allowed only on condition of being covered with clay.

House owners were either actively or passively hostile to having their gardens and tennis courts interfered with. I had considerable difficulty indeed in having an excavation intended for storing rain water between "St. Asaph" and "Oak Openings" filled up. It was 70 feet long, 25 feet wide, and 10 feet deep, and was overflowing on the morning of 19th September 1880. (Rain fell till past noon on that day. The landslide occurred on 18th.) In the afternoon of 19th it was empty, and on the 20th a note from Colonel Erskine, then owner of and living at "Braemar," told me that "Braemar" had suddenly cracked. The

excavation was over and a little to east of "Braemar." I had to move the Commissioner of Kumaun to get this tank filled with soil before the rains of 1881 had set in, and he issued peremptory orders before it was done.

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This order has generally been attended to. The exceptions to it are trifling, but I can specify them when I have more leisure.

(6) The further erection of houses, &c., within the limits specified.

This was arranged for by Mr. Willcocks. But his canal experience led him to use too easy gradients for carrying off roof water in masonry drains. On canals *so much fall per mile* is considered safe.

(7) Conducting house drainage to the most suitable ravine.

Here, as a rule, *any fall of less than 1 foot in 100*

This was my experience in canal construction on the Bhābar. Where you get less fall than 6 to 9 inches, the shale and debris lodge in the canal.

feet is useless. I could quote some instances where drains put round private houses by Mr. Willcocks failed to do the work expected of them, and as to iron

roof gutters, he put up a great many round private houses, which have since disappeared owing to the flimsy sheet iron and weak suspenders used. I do not want to reflect on Mr. Willcocks. He did splendid work and in a very short time. The King of Kumaun was reigning, Sir Henry Ramsay, and he told Mr. Willcocks that he was not to bother over plans and estimates, but he was to do so much work before the monsoons of 1881 set in, and he fell in with this and simply did wonders, so that minor details as to iron roof gutters or as to their durability are not to be put as "*per contra*." After a certain time a scare of security came on house owners, and with it a neglect of maintenance of proper roof drainage. Here, again, I would suggest personal inspection of all houses on Sher-ka-danda.

This was generally attended to, but a good deal remains to be done. Here, again, I invite inspection of the whole of Sher-ka-danda, so as to fix and describe certain neglected localities.

(8) Restoration of retaining walls by proprietors and sloping off of the hill above.

The Civil Officers in charge of Naini Tal have been changed frequently since this order was issued. They have from time to time issued orders, and these have been more or less obeyed; but it takes a man at least a year to learn what are the critical parts of Naini Tal. Very few officers have stayed over two years at Naini Tal since 1880. The honest, efficient, and trustworthy subordinate has to take his orders from men constantly being changed; so continuity of action is not to be expected.

(9) Civil Officer to be responsible for maintenance of all drains.

(10) Efficient and trustworthy subordinates to look after drains, &c., under orders of Civil Officer.

The remarks above given apply to (11).

(11) All operations affecting safety of Naini Tal to be under Civil Officer.

REMEDIAL MEASURES.

(12) All steep slopes to be turfed and planted.

I have not known of a single steep slope being planted and turfed, though it is clearly a necessity. Grass cutting and grazing are constantly practised. Many who commit the offence are brought up and punished, but the evil still goes on. Indeed, some influential Europeans do their best to protect their servants from punishment for such offences.

(13) Civil Officer to have power to carry out measures without reference to Municipal Committee.

The Civil Officer would have practically to neglect his civil and criminal work in kachahri if he devoted his time to enforcing this order and all preceding it.

(14) Civil Officer to have sole control of funds without reference to the Municipality. The advice of Superintending Engineer, Provincial Circle, to be obtained *when necessary*.

The Civil Officer on this order and in several previous orders is to act without reference to the Municipality. I do not think he has ever done this. There has always been some appearance of his having consulted the Municipal Committee, and during the last four or five years the Civil Officer and his Municipal advisers appear to have been quite set aside by the Government of the North-Western Provinces and Oudh. At present it is difficult to understand what use the Municipal Committee is, Government having apparently taken the initiative in every detail of public works at Naini Tal since 1890.

Since I resigned my post as a Municipal Commissioner in September 1891 I have naturally no knowledge as to details of the financial position of the Municipality. But it is well known that money is wanted badly to put Naini Tal straight.

Perhaps the Government that has just spent, without any petition being presented by tax payers, a large sum in improving the public recreation grounds will come to the aid of the Municipality for carrying out protective works.

NAINI TAL.
The 1st May 1895. }

F. E. G. MATTHEWS.

Report on the Southern Slope of Sher-ka-danda Hill,—September 1880.

I HAVE been asked to state what within my knowledge are—

- (1) The facts connected with causes of landslips in the past.
- (2) Date of building of houses or clearing of sites in the Rosamond's wall ravine or in any other locality.
- (3) Specify localities in which springs have broken out since my acquaintance with the station, and is there any connection between appearance of these springs with building of houses or clearance of sites above?
- (4) To offer suggestions as to remedial measures.

2. My observations during the past few days lead me to the conclusion that all of the ravines on Sher-ka-danda are more liable to slip on their eastern sides than on their western, and I will take ravine after ravine and try to explain what effect this has. The practical value of this (I can't call it discovery, as it must be subject of general note) may be *nil* or may be useful when proposing remedial measures. I beg to attach to this report a map which I think embraces

the whole of the hillside and houses now affected, or in the future likely to suffer unless proper measures are taken to protect them. As proportionately more houses are affected in the Rosamond's well ravine than elsewhere, I will take that ravine first. It is obvious to every one that the dip of the underlying strata of shale is in the general direction of east to west. The eastern edge being the higher and the western the lower, the tendency when any influences are brought to bear on this strata or on the soil and trees which conceal it is to slip downwards from east to west, that is to say, this would be the first direction taken by any moving mass, but the next movement would be undoubtedly southwards, that is, in the general direction of the Lake.

On the western bank of the Rosamond's ravine stand—

(1) Alma House, built in 1864. Western additions in 1868. *These last, though on apparently solid ground, have settled.* The old part is perfectly sound. The settlement is perhaps due to defective foundations. The retaining wall behind the house is bulged, indicating some degree of pressure from above, and the Alma Hill above is cracked. But I do not attach much importance to these.

(2) Alma Cottage, built in 1846. Removed in 1872 from its old site to one higher up. It is in perfect order, and would have been as good if rebuilt on its old site, which may be still seen between its upper and lower ranges of out offices. This estate *appears to be in dangerous proximity* to the Rosamond ravine, but from the fact that its drainage probably filters through the strata into the Glenmore ravine, no springs being visible in the precipitous western banks of Rosamond ravine; if it ever suffers, the Glenmore ravine will be the cause. Its rebuilding was caused by its general state of dilapidation, induced by old age, and the opportunity was taken to remove it further from the ravine. 2. On the eastern side of the Rosamond's ravine are (1) St. Cloud (on Dr. Walker's site), (2) Snow View (in map Himalaya House), (3) Alma House, (4) Blair House, (5) Brae Side, (6) Oak Lodge, and (7) Oak Cottage.

(1) St. Cloud, built 1874, has cracked, but not dangerously. The strata (or perhaps only the superincumbent soil) has sunk to westward.

(2) Snow View, built 1867, with its detached office in 1872. The house has cracked badly and settled to westward. The office is perfect.

The tendency of people who build on the crest of a hill is to excavate a much larger site than they could ever obtain on the side of a hill, and this has been carried out at both St. Cloud and Snow View, with the result of exposing large areas to the action of rain, and these kinds of excavations do also expose proportionately more of the underlying shale strata than sites on hillsides, the front part of which usually consists of made ground.

(3) Alma Lodge, built 1865, is at present as good as when first built. It is curious to observe how very close the head of the ravine is to this house. It probably owes its safety to the fact of the strata under it being supported by the opposite spur on which Alma Cottage stands, whilst Snow View and St. Cloud are, as it were, beyond the range of such support, or perhaps the strata under them dips a little more southward than westwards.

(4) Brae House, built in 1863, badly cracked and depending to westward.

(5) Brae Side, built in 1846, removed further east 1872, still further east 1875, badly cracked and depending to westward.

(6) Oak Lodge, built 1845, entirely unaffected. Probably its line of strata has been brought under control of the curved masonry walls built in the ravine after the slip of 1867?

(7) Oak Cottage, built in 1862. The sinkage of this house occurred in 1868 or shortly after, but no further damage has been caused. It undoubtedly owes its continued existence to the masonry in the ravine and also to the retaining wall on the road below it—from bridge to Marshall Cottage turning—and its existence also protects Oak Lodge above it.

3. Below this bridge a good drain conducts the water right past Charlton, which estate is neatly drained into the public drain, and as long as this exists there seems no danger to either this house or to Marshall Cottage above it, which is also drained into a good road drain, as the scour of the water cannot touch the toe of the spur. Once the bottom of the eastern edges of the ravine commence scouring and slips begin, there is no calculating what may happen. The kind of scour was most probably the cause of the landslip of 1867. The state of the ravine was probably neglected before that time, but the curved masonry walls and the stone drain afterwards introduced have saved till now the houses on the east side of Rosamond's ravine, and it is a pity that the opportunity was not taken from year to year to construct other walls *above those now existing in the ravine*. I would propose one, to drain into the northern gorge all the houses and such part of their grounds as can be embraced, and these are (1) Alma House, (2) Alma Lodge, (3) Snow View, and (4) St. Cloud, and I would have a special drain above Alma House, as there are some surface cracks in the Alma Hill which towers above it. The drain might be made of sufficient capacity and with a very steep gradient to ensure its keeping itself clear from such silt as might from time to time be carried into it by the hillside rills. A rude attempt at a drain does exist for the deviation of a small ravine by the outhouses. Hitherto it is evident that all of the drainage of Alma House and Cottage and Lodge has been conveyed *in a concentrated form* by one drain right into the head of Rosamond ravine, and the wonder is that so little damage has resulted! The wooden trough which finally conveyed this water right into the ravine disappeared in July last and was never replaced!

4. The drainage of Alma Cottage (on the western bank) might be carried into the Rosamond ravine or the Glenmore ravine, whichever is found best. The drainage of Blair House, Brue Side, Oak Lodge, Oak Cottage, can go nowhere else but into the Rosamond ravine, and I would catch the whole drainage of the following houses.

Beginning at St. Leo Cottage, a drain of *gradually increasing capacity* might catch the whole of the surface water coming from below road to Government House, and Brackenbury, built 1875, Tara Hall, 1875, and Plains View, 1875. These houses are not shown on my map, but exist between Blair House and Strachey site. I think the road which begins above the St. Leo Cottage and runs to westward until it joins the road which passes upward between Maldon and Oak Lodge on its way across the slip will be a good guide for this drain. *If a drain is at its upper end made on an easy gradient and lower down on a steeper gradient, it will not well*, and I think by re-aligning that part of this road from the gateway of Brackenbury downwards, this result can be obtained. It may, however, be found practicable to take a lower line generally, so as to secure some of the drainage of Maldon in this scheme, and here I would remark *that drains of which the upper part is steep and lower part less steep may carry water well, but can never be depended upon if any silt falls into them*. The whole of the upper edge of the hillside which would border this road ought to be protected by a good wall, and it is wonderful to observe how much safety is obtained by the most flimsy walls when covering exposed roadside cliffs. *NOTE*.—This scheme provides only for surface drainage and would not relieve the ravines lying between Edge Hill and Rosamond ravine of the sources which supplied their springs. Between Edge Hill and Ravenswood

ravines no springs are apparent. The Edge Hill and Maldon ravines being more precipitous and therefore more unmanageable than either Rosamond ravine or Ravenswood ravine, I would relieve them of all surface drainage which can be taken into the other two.

It will of course be indispensable, if this scheme finds favour, to thoroughly prepare Rosamond's ravine for this addition to its torrent. NOTE.—It is understood that the scheme which will drain St. Cloud, Snow View, Alma House, and Alma Lodge would be carried out, which would greatly relieve the Rosamond ravine, particularly of Alma Hill drainage.

The danger attending this measure will be to the houses lying to the west of Charlton, *viz.*, Belvidere, the kachahri, and bazár, but engineering skill will probably be able to devise proper measures below. With the fact that enormous deposits of silt already exist from below Charlton to the Lake, it will be difficult to obtain foundations for masonry drains, but perhaps massive wooden troughs, properly bolted together, would be the best conductor of water and silt from the lowest point up to which masonry drains would be safe. As this torrent would approach the Lake, the slope would get easier than it was above, and the consequence of this must be thought of. NOTE.—My observation on the attempt to continue a dry stone drain from below Charlton Lodge to the Lake is that though it acts for a time, it is invariably swept away during heavy flows of rain. Its gentle slope causes silt to deposit in its bed. Water overflows and forms numerous ruts in the silt, and the stone drain ultimately disappears. *Pakka* masonry might, however, stand.

5. The Glenmore ravine. This extended originally from below Glenmore to the Lake, passing by the bazár on its way, and was very narrow and tractable till within the past two years.

This year two small natural, but previously insignificant, ravines which came down from the Alma Hill crossed the Mall and proceeded, one to the east, the other to the west of Glenmore, until they joined in the main ravine, have scoured out and enlarged so as to threaten the existence of Glenmore also feed the main ravine and are developing into mischievous proportions. The eastern branch has extended so high up the hill that it will by and bye affect Alma House and Lodge. The western ravines will probably by and bye affect Tonnachy's. Glenmore House was built in 1845, and is in not much worse condition than when it came into my charge in 1873. It has long had alarming structural peculiarities, but they are not more prominent than before.

On the western bank of the Glenmore ravine are—

St. Helen's, built 1865.

The exposed scarp, three or four hundred feet high, extending from close under these houses, almost perpendicularly, into bed of ravine, appears no worse since I have known it, that is, since January 1872.

Blyth Cottage, also on west, built in 1848, is alarmingly near the ravine, but has not suffered. The houses on the east bank are, however, threatened, *viz.*, Springfield, built 1846.

I notice that the zigzag road which connects the bridge below Oak Cottage with the Upper Mall under Alma Cottage, has been acting as a drain, and has caused a small slip between Springfield and its retaining wall at the east corner, entirely closing the space. The water, aided by roof drainage, was compelled to rush past the back of the house and discharged itself into the ravine, between kitchen and house : *result*, scouring away of the bank right up to the west side of

house and destruction of the kitchen. Had much more water flowed here, the result would have been the total destruction of the house, which is *at present quite free from sinkage cracks*, and may be saved by judicious expenditure of money. A pathway ascending from behind kitchen has evidently also been collecting a lot of water and assisting in destruction of the kitchen.

Pilgrim Lodge, built in 1844. Last year rain caused part of the road between it and the ravine to slip down. Observe the roadside drain beginning under Springfield and discharging itself into Glenmore ravine, just above Pilgrim Lodge.

I connected this last year with the slipping of the road and protested. Then the drain was carried back so as to approach the ravine quietly. *NOTE.*—But the mischief was done. Some walls were built across the ravine last winter and also at foot of east bank and parallel to it; although these walls are too frail to last for ever, yet I hold that without them there would have been considerable slipping this year from near Pilgrim Lodge.

The slip has not extended appreciably, but this house is likely to become precarious, particularly if Springfield be hereafter destroyed, and if Springfield and Pilgrim Lodge collapse, the Club premises (the out houses of which are *now* in danger) must ultimately be destroyed. As a natural result, Norton House (now Hill's Hotel) will go too. I should think that from about the Club downwards all traces of strata disappear, the probability being that the gentle slope, on which are the Club and other houses round about it, including Hill's Hotel and the bazar, was formed by landslips occurring generations ago. The ravine from the Club downwards is tolerably impartial in its attacks, owing to absence of strata, and cuts freely into both sides, threatening Bridge House and Annandale on its west, and Club and Norton House and Norton Lodge on its east. Large trees have fallen into the bed at right angles to course from both banks, from the Club downwards, and these have, by impeding the water, produced excessive scouring to east or west, according as they fell.

It is probable that the whole of the Cheena Park estate and St. John's Church, Brookhill, and Girls' School was formed by landslips from Cheena centuries ago, as no strata are to be found hereabouts. *NOTE.*—And though this landslip soil is infinitely better packed and harder to break up than stratified soil, it may be easily scoured and cut into ravines if not watched.

A small ravine exists immediately to west of Blyth Cottage; the spring here is perennial, and has developed a great deal during the past two years, and discharges into the Glenmore ravine just at the Club. Another one, still further west, between Blyth Cottage ravine and immediately to east of Fairlight Glen and west of its outhouses, has from a small depression, scarcely 3 feet wide and 3 feet deep, *this year* developed into a formidable channel. It first enlarged in July 1880, when some 18 inches of rain fell in three days, and passing the small stone drain on Bridge House estate, which formerly sufficed to catch and carry off the water into Glenmore ravine, rushed into Bridge House and silted up the lower rooms. Between July and beginning of September I had made a stone drain for it as far as its course lay through the Fairlight Glen estate. Mr. Nicol had made a similar stone drain for it in place of the former smaller one, on Bridge House ground. The intermediate part, passing through Pavilion estate, was not protected; but as events turned out, that was of no consequence, as both upper and lower drains were torn up, and carried away in September on the morning of the day on which the Victoria Hotel was destroyed. A slip happened on the Upper Mall between Rookwood and Cheena Lodge, and this came down to the road which ascends over Fairlight Glen, and choking up the small culvert and ultimately destroying it, sent silt down to Fairlight Glen, completely burying the back of the house, and

forcing itself into all the rooms. I lost a man here, who was, with others, trying to turn the water and silt eastwards into its proper course. Three men were buried by a sudden onset of silt, but two escaped. There was always a small spring in this ravine, which became dry only just before the rains commenced.

It is curious to note that the slip on the Upper Mall is from the east bank and must have been caused by the scour of the water from Cheena slope, above the Mall, loosening the eastern base of the slope. There is a fissure in a small jutting knoll, attached to the eastern spur of Cheena, to the west of Tonnachy's (Fairlight Hall).

It is immediately within the angle of the road which ascends suddenly to Cheena, and the road which proceeds westward from Tonnachy's by a gentle gradient, down to the Mall, close to Stafford House. A little to the west of the knoll this road has been closed by a landslip of small and large stones, proceeding from near the upper end of the fissure, some of which have gone down to Cheena Lodge and have injured it. There is no doubt that this knoll will collapse sooner or later, perhaps (as it is to be hoped) gradually, or, most likely, suddenly, and the mass appears likely to affect primarily Cheena Lodge, Fairlight Glen, and Dak Bungalow, and secondarily, the Girls' School, Pavilion, and Bridge House, and perhaps Windermere. The same measures which would be needed to protect Rosamond's ravine will be needed in the Glenmore ravine. A series of semi-circular walls, beginning close to the bridge which crosses it near the bazar, must be brought right up the stream. Not far above this bazar bridge a road which existed on its south bank and passed up between Langdale (built 1844) and Annandale (built 1844) has been destroyed, and the upper part of this road is becoming deepened and will, if not ruled in time, acquire the dignity of a ravine, and ultimately destroy Langdale.

A drain which passes through Windermere (built 1845) collects water from pretty nearly the whole of Cheena, and has destroyed the bridge and road to Annandale, on its way to enter the Glenmore ravine. I would suggest that arrangements be made to drain as many as possible of the western houses on the Cheena Park estate into Sookha Tal, which is a natural reservoir. I would indicate here (1) Earl's Court, (2) Cheena Park, (3) Cheena Hall, (4) Kenilworth, and (5) Manor House. Of the two first a good deal of the drainage does go into Sookha Tal by the drain running between Petersfield and Ashdale, but the rest is all carried down alongside of the road between St. John's Church and Manor House and Brookhill, &c., into Windermere drain. Note.—The roadside drain is in a chronic state of disrepair and repair, and from its eccentric gradient is always silting up in places. Too much work is expected of this drain for its size. Look at the scouring out between Brookhill and Kenilworth and Manor House; at present it is not alarming, but what this may become in a year or two, if not ruled, we have witness of all over the station. Look at the scour inside Girls' School estate, bordering the road. The Glenmore ravine, it will be seen, is a very important one.

Its first feeder is the Blyth Cottage ravine, second Fairlight Glen ravine, third Windermere, which catches about half of Cheena rainfall, fourth the Langdale ravine, and it receives on its eastern and southern bank all the water from Springfield, Pilgrim Lodge, Club, Sunnyside, &c., &c.; in fact of the whole group of houses to west of bazar and Kachahri. With these facts as to its sources of supply, has the only bridge at present existing across it, *etc.*, that to north-west of bazar, sufficient waterway? The two which spanned it higher up—one near Club dormitories, the other near Bridge House—have been destroyed. Whilst near thana and tennis ground it was sought to confine the stream to a wooden-topped culvert of smaller capacity than those above it. The Glenmore ravine, allowing for percolation

from Sookha Tal and Ayarpata drainage, in fact conveys half of the drainage of Naini Tal into the Lake.

As much as possible of St. John's Church drainage might also be sent to Sookha Tal. There are several minor matters of which I have taken note, but they are not worth describing till more detailed enquiries are needed.

6. I will, before concluding the report, which embraces the whole of the houses connected with the Rosamond Well ravine and Glenmore and Fairlight Glen ravines, summarize their condition.

(a) Those absolutely cracked and unsafe for habitation till rebuilt:—

(1) Snow View (excluding its detached office).

(2) Blair House.

(3) Brue Side.

(b) Those dangerous till secured —

(1) Alma House, dry stone wall supporting bank behind bulged, hill above it cracked, a small part of western addition cracked and sunk. (2) St. Clond's cracks may widen next year. (3) Springfield slip extended right up to house, in fact edge of western bathroom and verandah is hanging over the slip. This verandah must probably be removed and not replaced. (4) Fairlight Glen, till protected from chance of future slips. (5) Bridge House, and (6) Pavilion, for the same reasons. (7) St. Helen's, and (8) Rookwood, till cleared from slips above them and *efficiently* protected from their recurrence. (9) Glenmore, till the ravines enclosing it are rendered safe from further extension. (10) Cheena Lodge, till the cracked knoll on Cheena is disposed of. *N. B.*—This knoll also affects *other houses*. I do not know if anything to the west of Cheena Lodge and Fairlight Glen is in the slightest danger and will now take up the case of houses further east.

New Government House.—This, in my opinion, needs as much, if not more, attention to the ground lying below it to westward than to the east. The collapse of the Victoria Hotel and the extension of the slip up to Maldon and almost up to Staff House is a serious matter. *NOTE.*—Between what may be called the Maldon slip and the ravine to west of Edge Hill the whole of the superincumbent soil appears disposed to slip off the underlying strata. I have seen numerous cases where such slips had begun years ago, large areas with trees growing on them having sunk and then stopped, and if the numerous fissures between Staff House and the Mission premises are dug out and closed, and all the numerous pathways which intersect it, and which undoubtedly do a lot of harm, are obliterated, and two, three, or four drains arranged in parallel rows on this surface to collect and discharge all surface water into the Edge Hill ravine, this slip might perhaps be checked.

The Edge Hill ravine must of course be prepared to receive this.

St. Loo, and perhaps Edge Hill, might be drained partly into Rosamond ravine, Staff House and part of St. Loo estate into Edge Hill ravine. A good deal of St. Loo drainage is caught by the roadside drain beginning at St. Loo (lower gate) and is discharged into Ravenswood ravine, just above Baugh Cot.

If the drain which I suggested from above St. Loo Cottage to Rosamond Wall ravine be carried out, there would not be so much left to provide against lower down. In my opinion, the collapse of the Victoria Hotel was mainly due to the following circumstances. Tura Hall, built in 1875, discharged through its gateway a large quantity of water, which crossed the road between it and Maldon, went through the Maldon estate, and finally crossed the road under Maldon, and shot

down the cliff overhanging the Victoria Hotel. During 1875, 1876, 1877, and 1878 there were scanty monsoons, but in 1879 this drainage destroyed the road under Maldon. This was not held to be sufficient warning, but a drain was, *some time this year*, constructed from under Staff House and was deliberately carried to the same spot. The breach in the road had been replaced by a good massive masonry culvert, and through this a terrible discharge of water poured for three or four days on to the Victoria Hotel. Maldon contributed part of its own drainage (*vide* the drain proceeding from it and passing in front of the kitchen), and a quantity of water was caught by the drain beginning under Staff House. Probably the whole of the Brackenbury and Tara Hall properties sent their water down by this channel on to the Victoria Hotel. I can't pretend to say that the hidden springs too were not fed by the large plateaus excavated for Tara Hall and Brackenbury. The great plateau of new Government House would probably affect Edge Hill ravine and the Mission premises most. *Last year* I noticed, for the first time, a great stream of water rushing suddenly out of the ravine immediately to east of Staff House. I was almost constantly employed during the heavy rain on Ayarpata at Edwin-stowe and Priory Lodge and could always see it. But the bulk of water disappeared before it got to the Mission premises in some mysterious way. A good deal of water used to run down and cut up the road above the Mission Chapel, but certainly not all of what appeared at the top ever *showed itself* below. This spout I at once attributed to Government House excavations, then in a somewhat chaotic state, and the chances are that the cracks now visible on the St. Loo estate are attributable to the saturated Government House plateau sending down its water. It is noticeable here again that the fissure extending from Staff House down to Edge Hill ravine indicate an intention of settlement to westward. The slip in the ravine, nearest to Edge Hill, which caused destruction of some of its outhouses, is also on the eastern bank, which has *fallen westwards*. The valuable Mission property below points to the necessity for walls and drains in the ravine which so nearly destroyed them. Till this is done I consider the entire Mission premises with School and Chapel and also the small Omnibus Cottage to east of Chapel dangerous to live in during wet weather. East of Government House, across the St. Loo Gorge, I think a different formation exists, which becomes more marked the further east one goes. Limestone boulders irregularly embedded in clay and shale are to be found, and here some unfortunate arrangements exist which with other circumstances may account for the fissures observable below.

(1) Mr. Fleetwood Williams, one of the Municipal Commissioners of Naini Tal, has a tennis court in a hollow to the north of his house, which must absorb a lot of water, as it is imperfectly drained. To the east he has an excavation of large size, which I saw certainly some three or four years ago. I saw this cistern on the morning of the 20th September, during a pretty smart shower of rain, and although over 30 inches of rain had fallen a few days previously, the cistern was empty!! As it stands over Braemar and the Bramley site, I make no doubt that the water which fell into it percolated under those sites. I did not observe how much surface drainage was conveyed into this cistern.* Further back, that is, to eastward of this cistern, a natural blind hollow exists, which borders the Larya Kanta road. A good deal of water can be caught in this hollow and though I can't say if it would affect the southern face of Sher-ka-danda, it might be judicious to either fill it in with soil or, by cutting a nick on its north edge, allow it to discharge to north.

(2) From the Bramley site enormous quantities of stone have been excavated for the building of new Government House. The trees which covered the soil have been felled and used for burning lime for Government House. One large house

* The late Mr. Petman informed me that he saw it *overflowing* on the morning of 10th. In the afternoon it suddenly became empty. It was 70 feet by 25 feet by 10 = 17,500 cubic feet!!

has been built on the site, with some ranges of out-offices and an immense area cleared for another house; drainage arrangements for these houses and sites either do not exist at all or are imperfectly completed. There are large hollows whence stone has been excavated, and the whole of the Bramley site may be looked on as a huge sponge for absorbing water. The Municipal Committee have, I know, been for months in a chronic state of discontent with these proceedings, but I can't remember that they ever actively interfered with them. I have no hesitation in connecting the destruction of Norfolk House *partly* with this state of affairs. It cracked badly last year, but the excavation on Bramley site had begun in 1877, and last winter some precautions and drainage arrangements were made, which apparently protected the house till the middle of September. The house, it is true, was badly constructed originally, and *that* has something to do with its collapse. It was begun in 1873 and not roofed in till just before the rains of 1875. Its out-offices were built in 1869.

The Ravenswood ravine has been widening and developing higher up the hill, particularly during the past two years. I will show some of the causes which are at work, assisted by 160 inches of rain in 1879 and 120 inches during 1880. From the road beginning at the St. Loo Gorge to the termination of it on the Mall, near the Mission School, may be observed a lot of arrangements tending to widen this ravine. 1. Observe that the drain which accompanies the road from the St. Loo Gorge is discharged at an angle of the road into Norfolk House grounds, to find its way as it pleases down the hill (ultimately this water assisted in the silting up of the Secretariat Office on the Mall). In reply to my protest as to this arrangement, *vide Naini Tal Gazette* for 2nd August 1879, page 4, proceedings of Municipal Committee, paragraph 12. 2. Observe that from this angle no drain accompanies the road up to the point where it crosses the Mall above Baugh Cot, and this bit of road is in good order. Before descending, look westwards and see a road, with its drain, proceeding from the St. Loo gate, discharging into the head of the Ravenswood ravine, whilst a culvert under the Mall here allows the ravine which separates the Bramley from the St. Loo estate to add its quota to the Ravenswood ravine. This is the only *legitimate* supply which I can see.

(3) The road descends to westward of Baugh Cot, and, making a sharp turn, descends to east under Baugh Cot, accompanied by a drain, which at the next turning is emptied into the Ravenswood ravine, just above bridge spanning road to Ravenswood. A small culvert which spans this drain at entrance to Baugh Cot generally gets choked up, and the result is that the water shoots across the road. It carried away the upper entrance to Edge Hill last year and again this year. Ultimately this water is caught below and sent off to Ravenswood ravine.

(4) A drain accompanies the road westward till the lower entrance to Edge Hill is reached, when it is allowed to cross the road and scour the hillside as it pleases. This ultimately is conveyed to the Ravenswood ravine. From the entrance to Edge Hill no drain accompanies the road westwards, and up to the next angle the road is in fair order, except just at the angle where settlement, which began two years ago, has been imperfectly attended to.

(5) A drain accompanies the road eastwards and at the angle is conducted into the Ravenswood ravine, just above Spring Hall outhouses, by a special drain and trough which crosses two natural drainage channels.

(6) A drain accompanies the road westwards, and is discharged into the Mission premises. It is fortunate that this drain is almost constantly impeded by small landslips, for if it acted thoroughly and constantly, the results of its invasion of the Mission premises would have been far more serious than are now visible.

(7) The road runs to east, accompanied by a drain. Look at the results of this discharge into ravine to west of Spring Hall. It is rapidly destroying the Spring Hall estate.

(8) The road runs to west accompanied by a drain down to the Mall. The water is *generally* shunted off by silt, brought from the Edge Hill ravine, into the Mission premises.

The Ravenswood ravine, it will be seen, has been getting more than its fair share of water to carry, and no proper efforts were made to secure its sides against scouring. Most of the dry stone walls which were put in during last winter and spring were hurled down.

The ravine beginning at the Ravenswood cistern and extending down to Fir Tree House produced silt enough to fill the lower storey of Fir Tree House last year.

It was resolved by the Municipal Committee that a drain of masonry was to be carried the whole way, and Mr. Bell was invited to co-operate to the extent of making the piece in his own estate.

Mr. Bell's bit was made, but the Committee's work, which was begun in three sections, was never completed. The upper and middle sections were not connected when the monsoons burst, and attempts were made throughout June and July to join them, which was not done till August. The middle and lowest sections were never connected. Result—first, deposit of silt at the beginning of Bell's drain caused the water to turn to the right, and take his drain in flank, which caused its destruction. During the latest rainfall the upper part of the drain above Lake View got silted up and the drainage burst through the Lake View outhouses and nearly destroyed Melville Hall and a range of outhouses, both *far to east of its proper course*.

East of the St. Loo Gorge the following houses are affected :—

(1) Oak Openings, but the owner is now taking down the front verandah and main front wall which settled last year, as he believes his agent did not put in proper foundations and placed the house too far forward. The settlement of his house is purely local and due to the bad foundations. But this drainage must be arranged for. At present it shoots down between Braemar and this property, then down between Kumann Lodge and Norfolk House. Here it is joined by some of the Bramley site drainage, and is cutting away the hill on the road just above Ravenswood cistern.

(2) Braemar has cracked slightly, but it is due to water effecting a lodgment near the house, and sinking of the main wall, which is not on so solid ground as the rest of the house. The site had been cleared many years ago by its former owner, Mr. Williams, and still further cleared in 1875-76 by the next purchaser, Mr. Hutchinson, so there was nothing to guide the placing of the house on it.

(3) The Towers was cracked badly last year and was taken down and rebuilt. It had literally no foundations. The site was depressed about 3 feet and the new foundations are sunk at depth varying from 10 feet in front to 2 feet at back. *The lines of cracks are exactly in the same places as those of last year.*

A good retaining wall was placed behind the house, and the drainage attended to. It seems as though the house (rebuilt on exactly old plan) was now planted inch for inch on the exact space occupied by it last year, and that the same causes which cracked it last year are at work this! But the masonry being all of good lime, with Lake bujree, the house may stand. *It may be affected by the road above*

the house, which has a drain accompanying it, from under St. Asaph to the St. Loo Gorge. Just near Braemar outhouses are some large limestone boulders, and into a cavity here this drain was emptied throughout last year. What became of the water ultimately I can't pretend to say. A protest against this arrangement produced the closing of this cave, and the water now apparently all goes to the St. Loo Gorge; but as the whole of the drain is of uncemented stones, I fear mischief is going on still. Mr. Lawder's new house is badly cracked, but I attribute that to the waterlogging of the soil. In June or July (I forget which) I noticed that the excavations for foundations of verandah (then not built) were as full of rain water as they possibly could hold. Subsequently the foundations were put in and verandah roofed, but the mischief must have begun then, in fact the arches had then cracked. I should say that *at present the site* on which the house exists is perfectly safe.

Ravenswood, built about 1848, is badly cracked, but is a very old house, built entirely without lime, and settlement of walls built in this way always shows exaggerated cracks. The worst ones appear to me to be to the *east*, which shows that the *Ravenswood* ravine has nothing to do with them. Possibly, when levelling the site, some caves were filled up with soil and boulders, and some of the boulders may have *tilted* lately, owing to the thorough saturation of soil. Between it and Rájpur I can see no fissures. At Rájpur there are numerous ones, undoubtedly connected with the ravine to its west.

Dudley Grove was built as badly as can be conceived, in 1865-66, with no lime in its walls, and originally thrown too far forwards. I had charge of this house in 1872, 1873, 1874, and in the winter of 1872-73, the front wall of the centre room, which is two storeys high and which was separated some 6 inches from the cross walls, I took down. I found it resting on loose soil. In rebuilding it I threw it back 5 or 6 feet, so that the room, which was originally 24 feet \times 18 feet is now about 19 feet \times 18 feet. I did not get satisfactory ground to build upon till I had excavated to a depth of 6 or 7 feet. In altering the flues of two chimneys I found nothing but mud had been used as mortar. I should not condemn this site; a less pretentious house, with low walls, would probably exist here with perfect safety. There is no regular stratified formation here, and the chances are that the site was carelessly levelled, and boulders have been tilting. *It was nearly in quite as bad a state at the end of last year's rains and was patched up*, so that its present state is due to the same causes as last year, *viz.*, thorough saturation of the site. The drainage arrangements were introduced only last winter, too late to save the house.

Bank House might be rendered safe by sloping off the shoulder of soil which overhangs it and by building a series of retaining walls above the house. A good drain might be brought down from under Dudley Grove to Ravenswood ravine, which would catch Dudley Grove, some of Ravenswood and Rájpur drainage. This would secure Newberry Lodge, Bank House, and Mayo Hotel from *surface* drainage; whilst another drain beginning at the same spot, under Dudley Grove, might proceed eastward into the drain above Fir Tree House (Secretariat office).

The Mayo Hotel may be saved entirely by massive masonry walls. To begin with, the walls which retain its terrace on the Mall are flimsy in the extreme, being too thin *and lime used too sparingly in their construction*, whilst those retaining the hill behind the house are of the same description. Look at the immense mass of the house and the tremendous weight, and note what very slight walls prove efficacious as a general rule in protecting high scarps.

Omnibus House (Mr. Fleming's shop) is in danger if the estate of Spring Hall is not attended to.

The Mall.—The eastern Mall is the only one which is being constantly destroyed by streams and silt pouring on to it from numerous ravines from the Mission

Chapel down to Mall House, and being at nearly the level of the Lake, it may be looked on as the termination of all the lines of drainage. Hitherto the silt which annually comes down is spread so as to widen the Mall. I think if it were used to raise the Mall, the whole surface might gradually become so elevated that silt and water could easily be conducted into the Lake. In fact, I would propose at once raising the Mall by excavating silt where broad expanses of it are lying at edge of Lake uncovered by water. When this is done there will be some chance of the various culverts which may cross the Mall acting properly. I would have none of these culverts arched over; good stout planked roadway would allow more space for floods and be easier removed and replaced when necessary.

And now I would beg to draw earnest attention to the way in which Naini Tal is governed by the Municipal Committee. That body is composed, without exception as to its European members, of Government officials who have all separate important public duties demanding their attention, from which fact they can devote but little time to the important duty of keeping the station in order. The brunt of the work falls on the Magistrate, who is their executive officer, and who has besides quite enough of responsibilities with his Judicial and Treasury work.

The Committee disperse in November, not a single European member remaining in Naini Tal, save the Magistrate, and he generally removes down with his Court to the foot of the hills for December, January, and February. During these months he pays visits to Naini Tal about twice a month, staying sometimes only a few hours, and occasionally for a day or two. The repairs of roads, drains, bridges, &c., during this time are carried out consequently with literally no supervision. I submit that the vast amount of capital invested in house property in Naini Tal is insufficiently secured from danger by this system, and that it would be well if the Government could take over the grave responsibility and place in charge of the station officers having special knowledge and in whom the public would have confidence. Some vigorous measures are necessary and a strong-willed officer needed who would have summary powers to compel such house owners as are not amenable to reason to carry out on their own estates plans which would fit into general public schemes. The funds at the disposal of the Municipality are large, and it is the fashion to say they are insufficient. But the manner in which they have been hitherto applied is the reason why they are insufficient. Look at these unnecessary items of expenditure :—

(1) A road was made round the Alma Hill in 1872, which cost Rs. 2,000. What is the use of this road?

(2) An iron water pipe has been laid to convey water to the St. Loo Gorge. It has cost Rs. 1,700. What public is benefited thereby?

(3) An iron tank fixed at spring under Oak Lodge is of doubtful general public utility. The money, about Rs. 500, spent on it would better have been applied to strengthening the Rosamond's Well ravine, in which the tank may some day be overwhelmed! This is one of the results of the cholera scare of 1878.*

(4) The road from the St. Loo Gorge has been entirely remade for the benefit of Government House at a cost of Rs. 700.

(5) A scheme was on foot lately to make a new road to the north of Government House, from St. Loo Gorge to Alma Gorge; another scheme for a cart road from the lower end of the Lake to the Chirta spur, whereon conservancy carts might run, and quite recently the advisability of reconstructing the Assembly Rooms on a larger scale was discussed at a meeting of the Municipal Committee, and all this,

* The outbreak of cholera induced the Committee to procure this iron tank for the protection of drinking water.

if considered in connection with the longstanding menace of the terrible landslip which has happened, with the wretched state of the roads and drains all over the station, the inference is that the Committee never properly realized the nature of the responsibilities which they undertook with such light hearts. They had a paid Secretary last year, who secured Rs. 4,200 as salary for 7 months, which is about one-fifth of the total sum earned annually by taxes on rentals, the main source of revenue!! He imported a lot of cast iron latrine fittings, which cost over Rs 1,300, and two iron conservancy carts, which cost over Rs. 700. This makes a total of Rs. 2,000 for goods which are now lying unused!

I trust that I may be excused for personally urging an immediate change of government. I am in charge of large properties and myself own two houses, and I think the present opportunity for plain speaking should not be missed.

F. E. G. MATTHEWS.

Naini Tal 31 August

To

J. R. PEARSON Esq.,
PRESIDENT, MUNICIPAL BOARD, NAINI TAL.

DEAR SIR,

There exists some misapprehensions as to what occurred at the time of the landslip of September 1880. A vague impression prevails that the landslip which overwhelmed the Victoria Hotel, and all damage which was observed and noted at the time in other parts of the station, were intimately connected. The proper way to deal with the period is to study the landslip and to see what caused it, how far it affected other adjacent localities, and why? The next thing is to study what happened in other parts of the station—the causes and effects—quite unconnected with the landslip at the Victoria Hotel, but merely co-incident with it, as occurring during the same days of heavy rain of the 17th, 18th and 19th of September 1880.

(1) Maldon, the property of Moti Ram Sah, had been, for some years, rented for use as Government House, whilst Staff House, a few hundred feet to its east, was retained for the Lieutenant Governor's Staff. New Government House was occupied in April 1880—and Maldon, consequently, was vacated. Brackenberry, Tara Hall, Tara Cottage and Plains View were built in 1875, and their roof drainage—particularly the three last named—became factors in the subsequent troubles. During 1876-77-78 the monsoons were mild, but during 1879 the enormous total of 140 inches of rain fell—generally however well distributed. *During 1878 (no use going further back in this connection) the roof drainage of Maldon was carried by a drain from the back of that house, to the east, and its contents were discharged over the hill-side on to the Victoria Hotel estate. (This drain is still in existence)* Dr. Walker resident in, and proprietor of Charlton Lodge, which estate was immediately to the north-west of the Victoria, got alarmed at the signs of an impending slip in 1878 and urged the Municipal Committee to do something, but nothing was resolved on till after the rains of 1879, which, as above shown, were very severe. The proprietor of the hotel was engaged, throughout those rains, in cutting channels in the soil—to the west side of his buildings, to keep the floods, from Maldon, away from them. *Throughout 1879, the drainage of Plains View and of Tara Hall and Cottage, carried by a channel, cut in the soil of the Maldon estate, added their volume to that of the Maldon drainage.* The Municipal Committee decided to make a masonry channel to bring the water from Maldon, past the hotel,—to its west—into the existing stone drain which carried flood water from Rosamunds ravine to the lake. *(Pray remember that the excavations made by the hotel people, to divert torrents were to the west of the buildings, and that the subsequent operations were also to the west).* The Magistrate was always accustomed to carry out all public works, in those days, and he was always the Vice-President. The Magistrate was then, as now, very frequently changed, but no matter how young, or inexperienced he happened to be, he was expected to be Engineer as well as Vice-President. Colonel Anderson had reigned as President, uninterruptedly, for many years prior to the landslip, but he took no part in the actual engineering work. The magistrate, after spending the cold weather of 1879,-80 at the foot of the hills, began the construction of the drain in

April, 1880. *He had a small drain made to bring the flood water of Staff House to the point where the Maldon water was shot over the hillside. (This drain is still in existence.)* He then began the drain from Maldon plateau down-wards-the work was in several sections-but the month of May was signalized by repeated and heavy showers of rain-in fact the monsoons may be said to have begun in May and did not cease till September. The inevitable result was that he could never connect the separate sections of his drain or even maintain in existence the work that had been done. At an early period of the monsoons the whole of the work was swept out of existence. The Magistrate, Mr. Leonard Taylor, was a splendid young officer and he frequently asked my help during the troubles with his drain, and as he was killed whilst helping at the hotel, for, obvious reasons, I did not give the above facts in my report at the time. I however, in that report, described the result of the Municipal Committee's attempt to make a masonry channel from the Ravenswood cistern down to Fir Tree House. The same officer attempted it and at the same time, viz. 1880. A reference to page 22 of part 11, will shew my report. *Plin North 1895.*

There is no doubt that the landslip was prepared firstly-by the blindness of those concerned in carrying a quantity of roof drainage to a spot unprepared to receive it, secondly it was precipitated by the well meant attempts to make a masonry channel at the wrong time of the year. The landslip destroyed the Victoria Hotel, the Volunteer orderly room, Bell's shop, and the Assembly Rooms. The hill slopes over the Mission premises and below Staff House, were found to have a series of cracks—parallel to each other. This slope is to the east of the spot where the landslip occurred and, no doubt, the cracks were caused by the shock to the eastern strata which had been resting against the fallen mass. No cracks were found in the slopes to the west of the landslip.

No other part of Naini Tal, than I have mentioned, was affected by the landslip. The house most likely to have suffered by it—Staff House, which is to the east of it, was absolutely unharmed, and is still quite sound. The cracks over the Mission premises were dug out and were filled with clay, which was well rammed, and the cracks have never since appeared. Mr. Willcocks accepted the tri-junction of the masonry drains from Maldon and Staff House, and the cutting in the soil from Tara Hall, as the point to start from, in making the existing drain which reaches the lake, passing close to the east end of "The Poplars".

In providing a masonry drain from the Maldon plateau to Tara Hall, he accepted the tortuous cutting in the soil which the owners had made to save Maldon from the Tara Hall floods and which the landslip rains had scoured out in a terrible manner. He simply lined the cutting with a masonry floor and sides. It is the most extraordinary looking drain to be found anywhere in Naini Tal being (to those who do not know the history of the period) inexplicably serpentine.

(2) During the floods of the 17th, 18th and 19th of September 1880, the ravine to the west of Edgehill, became widened and deepened to a very great extent, the silt from this ravine was carried on to the Mission Chapel, and completely buried it at the back. After accomplishing this, the surplus silt divided into two streams, which flowed on to the Mall. Two small

above Pilgrim Cottage, and another still stands, higher up the ravine. Oak Cottage, which is above and to the eastward of the bridge, subsided slightly at the time of the slip, and, for years after, its veranda posts might have been observed standing-out of the perpendicular. Oak Lodge which is above, and to the eastward of Oak Cottage, was not affected.

But Braeside, originally built in 1846, was badly affected. It was taken down and was re-constructed higher up, and more to the east, in 1872, but in 1875, it was again taken down and rebuilt on its present site. This supports my argument, delivered in my report of September 1880, *viz. houses standing on the east bank of a ravine (on Sher-ka-danda) have a tendency to move to west*. Brae House was built (above and to east, of Brae Side) in 1863. I am not aware that it was affected by the Rosamund slip. Snow View was built in 1867 (above Brae Side and Brae House). St. Cloud was built in 1874 (to the east of Snow View). Alma Lodge, built in 1865, is at the very head of the Rosamund ravine and is on the east bank. Its strata is bordered into opposite bank, which has not there been disturbed. Alma Cottage stands on the west bank, in a perfectly safe position. It was built in 1846, but some idea that it had become precarious after the Rosamund slip, induced the owner to dismantle it and place it, where it now is, in 1872. Its old site is visible between its two blocks of out-offices.

In September 1880 I reported that St. Cloud, Snow View, Brae Side and Brae House were affected by the ruins of that month, and all showed a subsidence to the west; whilst Plains View, Tara Hall and Brackenbury, were intact. Clearly they are out of the influence of the Rosamund ravine, although situated on its east bank. Alma Cottage and Alma Lodge were also entirely unaffected by the ruins of 1880.

(5) I have shewn in para (2) that the subsidences in the St. Loe grounds which began in September 1880 have never stopped but recur every year. I cannot say the same as to the east bank of the Rosamund ravine, with the same confidence, but it is doubtful if the "creeping" has entirely ceased. Mr. Willcocks, when constructing the protective drains and other works on Sher-ka-danda, dealt with the locality just described (as to its drainage) with a knowledge of its special weak points. In 1896 the P. W. D., no doubt from ignorance of the special conditions of the locality, made a lot of drains, about which I made representations to the authorities, but my warnings were ignored and a dangerous condition of affairs is maintained in the most ticklish locality in Naini Tal. *Viz.* on a narrow spur separating the first and second landships. Some of the troubles at Darjeeling were attributable to the long leads of drains, without intermediate relief channels, and this defect is characteristic of the P. W. D. works on this spur. One of Mr. Willcocks' drains has been unwarrantably deviated from its original safe course and its contents have been turned into a system quite unsuited to carrying it.

In 1898 the drains on this spur were breached in several places, and the result was a scour in the roads below Oak Lodge to an extent impossible to believe unless witnessed by the eye. Marshall Cottage estate was invaded and the house was buried by liquid mud at the back to a height of 14 feet. It cost the owner some hundreds of rupees to build breast walls. The Municipal Committee, though asked to meet me to inspect the extent of damage, more than once, refrained from doing so. I advised the owner to file a suit for damages, but he refused to do so.

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(6) Perhaps the Municipal Board will allow me to show them over the locality (having no fear of legal proceedings occurring in connection with the damage to the Marshall Cottage estate before them) and realize for themselves the existing danger.

(7) This paper has dealt with all of the most important localities, and it is not necessary to go into details of other places where damage in 1880 was chiefly, if not entirely, caused by defects confined to each locality—defects which the heavy rains of September brought to light.

(8) It seems to be clearly demonstrated that the east bank of the Rosamunds ravine has to be watched, as to its future influence on the houses upon, or near to it. Whilst all the houses to its west, need no attention whatever. The Glenmore ravine was lined with masonry from the Club right up the whole way. This was done in a scientific and thorough manner in 1880-81 and the ravine has not ever arrived at the stage of influencing the houses on its east bank.

It may be asked why Springfield, just above the Club, and on the very edge of the east bank of Glenmore ravine has not suffered. I think it will be found that Springfield is on "scree" material, with no traces of stratified shale under it, and therefore has no tendency to slip in any particular direction.

(9) The drain to the west of Edgehill was built by Mr. Willcocks in 1880-81. The falls are all built with lime mortar—but the floors, from the top of one fall to the base of the one above it, are of stone, without lime mortar. Unless during exceptional rainfall, *none of the water brought in to it from the branch feeders off the St. Loe grounds, arrives at the Mission premises.* There is a spring in the ravine, which starts in the grounds of Staff House: this ravine is a short distance to west of the Edgehill ravine and joins it before it reaches the Mission premises, and it is lined like Edgehill ravine with masonry, constructed in the same manner. The spring is perennial but during the monsoons, the outflow is considerable and *none of this water, ordinarily, is visible in the masonry drain which passes by the Mission premises.* From these premises down to the lake—which it reaches by passing between Murrays and Trevillion and Clark's shop,) the masonry is in lime mortar the whole way, and in smart showers of rain, during which other drains to its east and west are seen to be carrying heavy floods, a slight film of water in it indicates that it is probably carrying nothing but the rain actually falling into it, from the clouds, from the Mission premises downwards. Mr. Wildeblood in the cold season of 1895-96, had the stone joints of the kutchra floors pointed with lime mortar, but this could not be expected to endure. During the rainy season of 1896, considerably more water than before was, visible in this drain—but it did not show a tithe of what its sources of supply would warrant.

Having regard to the subsidence before described, as existing and steadily "creeping" every year, 2—to the fissures which were visible above the

Mission premises (which were closed and have not developed since) in September 1880, it would appear that the defects in this drain ought to be dealt with in a thorough manner as soon as possible. *Portland cement is being lavishly used to maintain other drains to its east and west in an impermeable state !*

(10) The publication of reports by geologists, and other experts, because of the troubles at Government House (now demolished) naturally excited a feeling of distrust as to the houses of private owners, in its vicinity and ruined their letting value. It may be inevitable, in the course of time, that the hills of Naini Tal shall disappear, but there is no immediate fear of this happening, and it seems to be necessary to keep in view the few weak spots, and to have well defined rules for their safe-guarding, and not to issue indiscriminate orders about a large area—the result of such orders being to create an unwarrantable amount of alarm.

(11) The only way in which the site of Government house could reach the lake under existing conditions would be by a summersault over the intervening slopes; which does not appear to be a reasonable thing to expect. ? Mr. Beresford's cool, sagacious, utterances on the subject are worth study. *Permit the Edgehill drain to extend unchecked to Brackenberry or a little higher up, it will then begin to exercise an influence upon Government house site.*

(12) Before concluding it may be as well to make some quotations from the "Report on the geological structure and stability of the hill slopes around Naini Tal" by Mr. T. H. Holland. 1897.

Para. 25.—"Mr. Matthews' report describes the condition of a large number of sites on the western face of Sher-ka-danda, where he shows the movement to be not directly towards the lake, but in a more westerly direction following the dip of the stratification planes of the slates. As I hope to show in the sequel, this is a most important consideration in dealing with the question of the safety of special sites, and one which, so far as I can find from the records, has been practically overlooked, or at least not mentioned in the same precise form in previous reports on this hill side."

Para. 91. "Consequently a house built on the western bank of a ravine might be safer than one on the eastern bank, although the latter is on a very much gentler slope. The facts relating to the houses on the Rosamund's ravine, detailed in Mr. Matthews' valuable report, confirm this conclusion most strikingly."

Para. 105. describes the subsidences in the St. Loe grounds referred to in para 2 of this paper, and concludes by:

"According to the evidence of Mr. Matthews these depressions did not exist when the roads were made and being in a line with the portion of the drain referred to by Mr. Oldham as transversely sheared, may be taken as evidence of subsidence having taken place along the stratification planes of the slate."

Para 120. " As long as Edgehill and Ravenswood stand, the hill under Government House is, I consider, absolutely safe. Even if Edgehill should slide down into the lake, the foundations of Government House will be no more affected than those of St. Cloud were by the landslip of 1880."

To sum up: The movements in the St. Loe grounds I have repeatedly written about, and also the unsatisfactory state of the masonry of the drain to the west of Edgehill. In my letter to the President of the Municipal Committee dated 1st of May 1895 they are treated of in paras 5 and 6 (of that letter) which will be found in page 9 of part 11. of the Bluebook.-1895.

Yours faithfully,

F. E. G. MATTHEWS

